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The Annual Meeting

IT is hard to appreciate fully the part automotive vehicles have in our national life, not to mention the development that is to come in passenger cars; motor trucks; farm, military and industrial tractors; motor boats; aircraft; semi-portable engines; and farm lighting units. It is clear that the form and extent of use of these are in their infancy. One's mind can grasp only in a general way what will be the manner and effect of the economical design, production, use and servicing of tens of millions of these vehicles. The intellect of a Jules Verne or an H. G. Wells is not adequate for the visualization of what the automotives will be and do.

In the effort to restore that proper economic balance which is essential to national prosperity the automotive engineers will play their full part. That was fully demonstrated at the sessions of the Society held in New York City last month at which the attendance was over 30 per cent larger than it was at the corresponding sessions last year.

It is said that the American farmer produces four times as much food per human unit as the European; he replaces three men by using horse or power-driven machines and decreases the cost materially. Were it not for plows, harrows, rollers, cultivators, seeding machines, trucks, tractors, hay-making tools, harvesters, threshers, gas engines, diggers, dairy machines and appliances and hundreds of other tools and machines, the production of our farms would be one-fourth what it is. The work of the members of the Society is very largely concerned with motorization and the application of machinery of which the internal-combustion engine is the heart, to the fundamental operations of production and distribution of the staple articles of commerce.

The automotive engineer is preparing for the greater and greater intensification of machine and traffic methods that will inevitably come in this country, and for world-wide trade on which all our operations are so widely based. In this he is not forgetting sane requirements in the demand for the various types of automotive apparatus, or the vital necessity of the maintenance of standardization that will make possible that interchangeability of many materials, parts and accessories that is economically requisite. Many of the benefits of civilization are furthered by the activities of the Society.

At the dinner, George E. Roberts pointed out that if anyone knows what is the matter with the world at the present time, it is the engineer. With the division of labor in industrial development, the engineer devised ways and means to increase productive power as a whole. The loss of the world equilibrium, the equilibrium in world trade, has cost us a state of equilibrium in this country, notwithstanding the fact that owing to our resources being so varied and so great we are more nearly independent of the rest of the world than any other country. Mr. Roberts' theme was that there cannot be a state of general prosperity in either international trade or domestic affairs without an equilibrium in industry; that there cannot be a full distribution of products or full employment unless industry is in balance, all business in the last analysis being simply an exchange of products. The town industries and the great farming industry, together with the people immediately dependent upon it, must be brought into a comparative state of balance. All of the wage earners in an industry together do not have in their power the fixing of the amount of the wages that will be paid in the industry, because the amount of wages that will be paid depends upon the amount of goods that can be sold, and in turn the amount of goods that can be sold depends upon the ability of the public to buy. The engineer has shown the whole world how industry can be revolutionized by highly organized production. The engineers have done more than any other group of men to teach the lesson that the essential thing about wages is not the wage rate per week or per day but the cost of labor per unit of product. That is the golden key to the solution of the entire industrial problem. The people of this country must understand that they are vitally concerned in large-scale increasing production. There is no limit to the benefits that can be derived in this respect.

In connection with the expansion and restriction of credits, Mr. Roberts said that it is an established fact that people in general never use the earnings of good times to pay their debts but use them as a basis for further borrowing. People make their debts in good times and pay them under pressure in hard times. The condition of this country is remarkably good considering the experience through which we have passed and the readjustments that were absolutely necessary. In other similar situations in our history the reaction in business has come from a period of expansion during which there was a great amount of development and construction. We have had a period of expansion due to our expenditures in war, this being stimulated by war business. The country is much underbuilt today. There is a great backed-up demand for development and construction work which will be done speedily provided the general conditions in industry are favorable. There are millions of automobiles which ought to be built, and airplanes should be produced, as well as enormous amount of other automo-

tive apparatus; and they will be built as soon as the industries of the country are brought back into balance.

Toastmaster Kettering expressed the view that the members had never attended a banquet at which they received more real substantial information, this dinner giving a new perspective of our whole business situation. He said that the engineers understand what the sales department wants: something they can sell; that last year the sales departments blamed the designing and producing engineers because automotive apparatus was not turned out fast enough, and say now that the trouble is that it is not good enough.

Vice-President Cowie, of the American Railway Express Co., argued that there is no reason why the United States Government should not give as much support to commercial aviation as it does to water navigation, and that it is absolutely imperative that models of commercial airplanes which can be readily altered to become effective weapons of war should be developed. He said that the great work that the automotive industry did during the war was possible because that industry was fundamentally sound and operating on a proper basis, the manufacturing of vehicles being so standardized as to make their rapid conversion practical. Although America is the home of the airplane, nothing important seems to have been done by the Government to conserve our valuable aeronautical assets. Mr. Cowie emphasized the great necessity for immediate encouragement of commercial aviation.

In connection with transportation in general, Mr. Cowie pointed out that the problem is one of coordinating a great number of different types of mediums ranging from wheelbarrels to airplanes, and including trucks, single-horse and double-team outfits, automobile trailers, double-end electric platform trucks, automobiles, gasoline engines, tractors, electric trucks and experimental airplanes and dirigibles. He urged the need of simplifying motor vehicles; stripping the chassis until nothing is left but those things that are essential for efficiency. He believes that such procedure will reduce costs in production and operation and increase sales greatly. Mr. Cowie is a great believer in future aviation, saying that in this country of vast distances and unexplored resources transportation is a paramount matter, the cost of it determining largely selling price. This phase of his argument makes clear the great and far-reaching opportunity before the automotive engineer.

David Beecroft, president-elect, in discussing the major activities of the Society, referred to its including in its circle of membership eight distinct but closely related industries, all centered about the use of the internal-combustion engine. Inasmuch as the apparatus produced by the members goes into the hands of the average citizen of all the countries of the world, it is vitally necessary to carry rationally to the user a message explaining how the apparatus should be used. He said that the apparatus has by no means reached the status of perfection. In the motor car, the oldest and largest member of the automotive circle, many problems are to be solved. He referred to the great influence the internal-combustion engine has had in bringing the rural population up to the level of urban conveniences and comforts. We have the great world field before us. With factory capacity expanded greatly during the war, we must give attention to the needs of the rest of the world. The motor vehicle is an international piece of mechanism in all its forms and the members must look beyond the confines of their own country and scan the conditions under which the vehicles they produce must operate in many different countries. Local conditions must be recognized, the goal in mind being service to not only this country but all the countries of the world, the automotive apparatus being as easy of application, operation and maintenance as possible.

Aeronautical Engineering Session

The aeronautical engineering session, directed by Glenn L. Martin, aroused considerable interest and was attended by 210 members and guests. The paper on Airplane Propellers by F. W. Caldwell, read by L. E. Pierce in the absence of the author, outlined the progress made in propeller design and construction during the past year. Mr. Caldwell described the various blade forms most generally used and told of the perfection of a method of molding propellers from a composition under great pressure. Testing methods for studying propeller performance have been improved and it is now possible to record torque and thrust readings under actual flying conditions. The advantages of reversible-blade propellers were referred to by the author, tests conducted by the Government which had demonstrated the practical value of one experimental propeller of this type being mentioned. Grover C. Loening read a paper on the Design Requirements of Commercial Aviation. Single and multiple-engined types of commercial airplane were compared, the author drawing conclusions which favored designs providing for the installation of only one engine. Mr. Loening recommended the use of all-metal and wood-and-metal construction in combination, believing that each has a place in certain parts of the airplane structure.

C. D. Hanscom in his paper on Airplane Wings, described some recent wind-tunnel tests of new wing sections and presented curves indicating the characteristics of these sections which showed that unusual efficiencies had been attained. He also outlined the results of tests which gave an idea of the effect of adjustable front and rear wing flaps on lift and drift, demonstrating the benefits resulting from the use of variable-camber wings. Major Thurman H. Bane was unable to present his paper on the Progress of Military Aviation but was ably represented by Major H. S. Martin, who gave a very interesting description of the recent work done at McCook Field. Pictures were shown of experimental aviation engines of unusual types, the latest models of war planes and the new airplane cannon developed by the Ordnance Department. The motion pictures of parachute jumps were very entertaining and impressed the members with the practicability of the parachute as a life-saving device.

Annual Business Meeting

President J. G. Vincent was in the chair at the annual business meeting held during the morning of Jan. 12. After expressing his appreciation of the splendid support and cooperation accorded him during the past year by the officers and members of the Society, he gave a comprehensive survey of the Society's activities during this period.

In reference to membership, it was brought out that there is a net gain of 715 members for the year as compared with 651 for the previous year. The activities of the various Sections were considered as having been highly commendable and the belief was expressed that the Sections are experiencing healthy growth. The work of the administrative committees was pronounced most satisfactory as to both volume and quality, under condi-

tions that had made this work more than usually burdensome.

Passing then to the work of the Standards Committee, President Vincent summarized its comprehensive activities, stating that in one sense the real value of standardization is just beginning to be realized, and suggested that doubtless much more can be done by way of simplifying, facilitating and improving the manufacture of the products with which the automotive industry is concerned and the economical use of which in service must be fostered. He then enumerated the many present cooperative activities of the Society with the work of other societies and organizations in allied fields, inclusive of active cooperation with various bureaus and departments of the Government, placing emphasis upon the solution of the fuel problem. It was suggested, however, that there is a limit dictated by common sense to the scope of coordinated activities that can be beneficial jointly or severally and that, with regard to both the domestic and foreign affairs of the Society, this should operate to protect it from too great complexity of effort. In this connection and also concerning the relation of the Society to the Federated American Engineering Societies, it was stated that a properly conservative policy indicates the assumption of a continuance of the Society's previous attitude of close attention to automotive matters in practically the same degree as heretofore.

The efficiency of the organization and the work of the Council and the office staff of the Society were commended and comparisons in regard to the Society's remarkable growth were made, inclusive of financial and publication statistics. Since the time that Coker F. Clarkson became Secretary and General Manager of the Society 10 years ago, at which time the office equipment consisted of desk space in an office, there were less than 400 members and Mr. Clarkson was the sole employe, the office staff has increased to 50 persons, the office space required is 7500 sq. ft. and there are over 5000 members of the Society resident throughout the world.

President Vincent then discussed the future activities of the Society at considerable length and indicated desirable procedure along the lines of standardization, both national and international, foreign relations, the work of the proposed Research Committee recently authorized, committee and Sections' work in general and the work on internal-combustion engine fuel. The future problems of the automotive industry were enumerated and commented upon by him in considerable detail, these being inclusive of the successful quashing of the present general idea that the passenger automobile is to a large extent a luxury, the prevention of possible greatly increased taxes on automobiles and trucks, the need for a Federal licensing system because of the increasing amount of interstate commerce by motor truck and the removal of the three handicaps—road construction, fuel and cost—which must be accomplished before the automobile can render its full service to this country. The obstacles to the removal of these handicaps upon the industry were specified and an outline of much practical value for overcoming them was given.

The final portion of President Vincent's address was devoted to a summary of aircraft development and a discussion of its possibilities. It is evident that there has been a steady improvement in the reliability of the airplane, an extension in the use of aircraft where this was justified by the inherent advantages of this system of transportation and attainment in the field of research limited alone by the funds available. President Vincent stated further that perhaps the most conspicuous tendency in airplane engine design is to pay more attention to efficient operation at altitude and under reduced throttle conditions obtaining during average flights. This involves in some cases special precautions against running wide-open near the ground, except for short periods with the aid of special fuels to guard against preignition and detonation. In this manner it is possible to effect considerable savings in fuel consumption at altitude, together with an increase of available power under normal flying conditions.

The following resolution relative to the status of the proceedings at the 1920 Summer Meeting at Ottawa Beach, Mich., was then presented by T. C. Menges and was adopted.

> *Resolved*, that all acts of the Society done by it at its meetings held in Ottawa Beach, Mich., June 21 to 25, 1920, and all resolutions adopted by it at these meetings, be and the same hereby are in all respects confirmed, approved, ratified and adopted, as the acts and resolutions of this Society with the same effect as if they had been adopted by this Society at a meeting held in the State of New York; and be it further
>
> *Resolved*, that any and all the acts of any of the officers of the Society done under any of the said resolutions be and the same are hereby confirmed and ratified.

Financial and Membership Reports

The report of Treasurer C. B. Whittelsey for the fiscal year ended Sept. 30, 1920, showed the total assets of the Society to have been $151,627.39. The total liabilities were $21,977.31, making the unexpended balance in the treasury $129,650.08 at the end of this period. The income for the year, including initiation fees, dues, publication, advertising and miscellaneous sales, and contributions and interest, amounted to $247,206.55. The operating cost for the year was $227,650.43, which leaves $19,556.12 as the unexpended income for the last fiscal year and is a commendable result.

The report on the membership of the Society was to the effect that the average number of applications received per month during the past seven months was approximately 90 as compared with an average of approximately 77 per month during the same period of 1919. The total number on the rolls of the Society on Jan. 1, 1921, including Affiliate Member Representatives and Enrolled Students, was 5231, constituting a net gain of 465 since June 1, 1920, after 108 had ceased to be members owing to resignation or non-payment of dues. This is a net gain of 715 members for the year, as compared with 651 for the previous year.

The increase of membership since December, 1909, is shown in Table 1.

TABLE 1—INCREASE IN MEMBERSHIP

Year ended Dec. 31	Total Members	Percentage Increase
1909	393	....
1910	654	66.4
1911	982	50.1
1912	1,447	47.3
1913	1,713	18.4
1914	1,743	1.8
1915	1,783	2.3
1916	2,121	19.0
1917	3,284	54.8
1918	3,986	21.4
1919	4,516	13.3
1920	5,231	15.8

In Table 2 the membership is analyzed by grades.

TABLE 2—MEMBERSHIP ANALYZED BY GRADES

Grade	1919	Percentage of Total	1920	Percentage of Total
Members	2,360	52.3	2,706	51.7
Service Members	13[1]	0.3	18[1]	0.3
Foreign Members	11[1]	0.2	50[1]	1.0
Associates	1,350	29.9	1,495	28.6
Juniors	514	11.4	692	13.2
Affiliate Members	95	2.1	112	2.1
Affiliate Member Representatives	110	2.4	117	2.3
Enrolled Students	63	1.4	41	0.8
Total	4,516	100.0	5,231	100.0

[1]These figures do not include all the members resident abroad or employed by the United States Government.

Table 3 shows comparative figures regarding the number of applications for membership during 1918, 1919 and 1920.

TABLE 3—APPLICATIONS FOR MEMBERSHIP RECEIVED

Month	Year 1918	Year 1919	Year 1920
January	65	74	69
February	49	82	93
March	45	83	101
April	56	100	166
May	126	78	173
June	107	69	103
July	71	54	76
August	88	23	104
September	76	71	82
October	59	107	70
November	122	111	113
December	102	100	73
Total	966	952	1,223

REPORT OF THE COUNCIL

The substance of the report of the Council is embodied in the Treasurer's Report, the report of the Membership Committee and the list of members elected during the past year. In addition, Mr. Clarkson touched briefly on a few other specific and general matters.

Table 4 shows the large amount of publication work accomplished during the last fiscal year.

TABLE 4—VOLUME OF PUBLICATIONS FOR THE FISCAL YEAR ENDED SEPT. 30, 1920

Publication	Number of Copies	Pages per Copy	Total Number of Pages
THE JOURNAL	74,000	200	14,800,000
TRANSACTIONS			
Part II—1918	4,500	500	2,250,000
TRANSACTIONS			
Part I—1919	4,300	810	3,484,000
Data Sheets	592,000 leaves	..	1,184,000
Membership Roster	10,000	325	3,250,000
			24,968,000

In the Statistical and Addressing Department of the Society the members' list or roster is kept in card form, alphabetically, by company, geographically and by position held. This one file contains over 20,000 cards, each card being cross-referenced five times for easy accessibility of information. During the past year there were 5800 additions and changes in the above-mentioned cards. This means that 58,000 individual cards were changed during the year, besides other records and reports of the changes sent to the Sections and other departments. All mail returned from the Post Office for better address is referred to this department and the sendee is systematically followed up until found and the address corrected. The envelopes for all general notices being mailed to the membership, the wrappers for the mailing of THE JOURNAL and labels for the mailing of sundry publications, are all addressed by machinery in this department.

Mr. Clarkson then presented the following interesting analysis of costs, the figures being based on the total operations, including meetings, of the last fiscal year.

(1) The unexpended income was 7 per cent of the turnover
(2) The salaries amounted to 34 per cent of the turnover
(3) The expense for drawing, engraving, printing and binding amounted to 26 per cent
(4) The meetings expense, including the cost of hotel accommodations, dinners and meeting rooms, was 13 per cent
(5) Rent and improvements were 4 per cent; postage, shipping, telephone and telegraph expenses, 4 per cent; stationery and supplies, 2 per cent; traveling expenses, 2 per cent; and miscellaneous expenses, 8 per cent.

The average cost per member for the last fiscal year is stated in Table 5.

TABLE 5—AVERAGE COST PER MEMBER

Activities	Cost per Member
Publications	$15.67
Standards	4.33
Meetings	12.74
Membership Increase	1.50
Sections	1.90
Rent and Improvements	3.26
General Administration	18.44
Cost of Sales	0.83
Total	$58.67

The expense of the Standards Department during the 1919-1920 fiscal year was slightly over $31,000, including general administration overhead. The corresponding figure for the Sections Department was $13,800. The cost per member of meetings of the Society held last year is given in Table 6. After adding general administration overhead and deducting the income from the meetings mentioned in Table 6, the net expense per member for all of the meetings was $10.65. The cost of the Accounting Department for the fiscal year was $6,426.09, and that of the Stenographic Department $10,475.39.

TABLE 6—COST OF SOCIETY MEETINGS PER MEMBER

Meeting	Cost per Member
Aeronautic	$0.33
Chicago	1.24
Kansas City	0.34
Motor Boat	0.07
Winter, annual	4.12
Summer, semi-annual	5.62
Meetings Department and Sundries	1.02
	$12.74

The direct cost of holding Council meetings during the period in question was $514.21. The postage bill of the Society for the fiscal year was $7,350.64. The telegraph and telephone expense was $2,154.87 and the traveling expense of all departments was $6,651.09. These are typical items of the operations of the Society.

Regarding the present status and growth of the auto-

motive industry, as indicating the volume and complexity of the future work of the Society, Mr. Clarkson went on to say that if one glances back to the time of William Shakespeare, the greatest of British poets, one will recall that in 1586 he made his way to London in search of work and opportunity. London at that time had 150,000 inhabitants. In those days there were two well established routes from Stratford-on-Avon to London. The roads were few, bad and dangerous. Journeys were made in the saddle or on foot; there were no other methods of travel. Goods of all kinds were carried by pack-horses; wagons were very crude and very rare. It should be borne in mind that vehicles were not run as public conveyances until the seventeenth century was well under way.

Today, at least 8,500,000 automobiles, passenger cars and motor trucks, are in greater or less use in the United States. There are, in addition, nearly 400,000 farm tractors; more than 1,000,000 stationary engines of the internal-combustion engine type; and probably over 200,000 motor boats. These machines, approximately 10,000,000 in number, consume a large percentage of the 100,000,000 bbl., more or less, of gasoline produced annually, and a large amount of kerosene.

In 1923 there will be in use, allowing for machines discarded after five or six years of service, probably more than 9,000,000 passenger cars; close to 2,000,000 motor trucks; upward of 1,000,000 farm tractors; and more than 1,500,000 stationary engines. This means, without counting aircraft, over 13,000,000 machines of the various types mentioned, if the economic and financial balance hoped for is restored soon.

As we reach and advance from this stage we shall need another Shakespeare to visualize and guide our activities. In any event our work is cut out for us on a very large scale. The Council bespeaks accordingly the best effort and aid of all the members of the Society in conformity with its established precedents and in continuance of the remarkable loyalty and the generosity of the members that have made the achievements of the Society possible.

Report of the Standards Committee

The Standards Committee reported for approval at the meeting 34 recommendations; 13 were on new subjects, 17 involved revision and extension, 3 were cancellations of previously accepted recommendations and 1 was a special report. In January and June, 1920, there were reported 48 and 49 recommendations respectively, by 14 Divisions. The number of Standards and Recommended Practices contained in the new edition of Vol. 1 of the S. A. E. HANDBOOK, recently issued in rearranged form, is 210. The Committee has now in hand in various stages of progress more than 200 subjects. The specific action taken with regard to standard recommendations at the Standards Committee meeting held Jan. 11, 1921, is reported in full in this issue of THE JOURNAL.

Sections and Meetings Committee Reports

Thirty meetings have been held during the past year by the 10 Sections of the Society, the subjects discussed having been related not only to engineering problems but to the economic trends of today. The Section established in Boston and the Section continued at Washington after the war period have been successful from the start.

The Meetings Committee report enumerated the important general meetings of the Society held during its 1920 administrative year and stated that there had been a total attendance at these meetings of approximately 2500 and an attendance at dinners held by the Society of about 2800.

During the summer and autumn of 1920 the Society participated in meetings of the National Gas Engine Association at Chicago, and of the American Petroleum Institute at Washington. During the year, 93 papers were presented, classified as follows: Aeronautics, 14; bodies, 6; fuel, 28; motor boat, 8; passenger car, 8; farm tractors, 6; transportation and highways, 10; motor trucks, 6; and general topics, 7.

Election of Officers

T. S. Campbell, Glenn Muffly and C. E. Heywood were appointed as tellers of election of officers to serve during this administrative year and of Councilors to serve during 1921 and 1922.

They reported that 917 valid and 14 invalid ballots had been cast, 884 of the valid ballots having been according to the nomination and 36 miscellaneous. The total count on election is as follows:

	For	Against
For President (To serve for one year)		
David Beecroft	910	7
H. W. Alden	1	
W. P. Chrysler	1	
H. L. Horning	1	
For First Vice-President (To serve for one year)		
H. L. Horning	911	6
A. W. Scarratt	1	
David Beecroft	1	
For Second Vice-President Representing Motor Car Engineering (To serve for one year)		
B. B. Bachman	910	7
H. L. Elfes	1	
A. T. Sturt	1	
For Second Vice-President Representing Aviation Engineering (To serve for one year)		
H. M. Crane	912	5
For Second Vice-President Representing Tractor Engineering (To serve for one year)		
E. A. Johnston	904	13
D. P. Davies	1	
A. W. Scarratt	1	
For Second Vice-President Representing Marine Engineering (To serve for one year)		
Joseph Van Blerck	910	7
For Second Vice-President Representing Internal-Combustion Stationary Engineering (To serve for one year)		
T. C. Menges	911	6
For Councilors (To serve for two years)		
W. A. Brush	905	12
F. W. Davis	914	3
H. A. Coffin	1	
Allen Loomis	1	
Horace Smith	1	
For Treasurer (To serve for one year)		
C. B. Whittelsey	915	2

Those receiving the largely preponderating numbers of votes were the nominees of the regular Nominating Committee, no other nominations having been made, and were declared elected. There are 15 voting members of

the Council. Ten have been newly elected as stated above. The others are Past-President Vincent and Councilors F. M. Germane, N. B. Pope, A. W. Scarratt and Glenn L. Martin. The first four are holding over in accordance with the provisions of the Constitution and Mr. Martin was chosen by the Council to fill a vacancy which existed.

Remarks of President-Elect Beecroft

As soon as the report of the tellers was accepted President-Elect Beecroft was escorted to the platform and made a few remarks. He said in part:

> The volume of work and the importance of the Society as we have seen them develop under the very able leadership of Colonel Vincent during the past year, impress me with the seriousness of the responsibilities that rest upon the President of this Society.
>
> I pledge you the very best that I can give during the coming year, and that will be very largely the result of the excellent Council that has been elected this morning. It will be a great pride and one of the highest honors in my life to have the opportunity of giving aid in guiding the activities of the Society of Automotive Engineers during the year 1921.
>
> My familiarity with the activities of the Society in the last four or five years, during which time I have been connected with the Meetings Committee, has given me an opportunity of looking into the possibilities of the Society; and what Colonel Alden, Mr. Crane, Mr. Moskovics and Colonel Vincent have said this morning regarding the responsibilities of the engineer, makes me feel the load all the more.
>
> We are approaching new problems each year in our industry. Some years ago the sole problem, let us say, was that of design. Then we approached the greater problem, five years ago, of production. To those problems we have added today that of maintenance, because we must not forget that we have 9,000,000 motor vehicles in the different countries of the world, and that it is just as essential that they be kept at a standard of efficient operation and scientific application as it is that we go on building more. I feel that the Society must give more attention to that aspect of the work; and I would like to subscribe in a general way to what Colonel Alden and Mr. Crane said as to the necessity of the engineer having a wider vision, a world view, of our industry and his part in it.
>
> I wish to thank you very sincerely for the unexpected honor of being elected President of the Society, and I again pledge you that all that I can do in 1921 for the pushing forward, uplift and constructive advancement of the Society will be done.

Addresses

Following the regular business session, President Vincent called upon H. M. Crane, Col. H. W. Alden, F. E. Moskovics and J. G. Utz to express their views regarding The Engineer's Place in the Industry.

Remarking upon the comparatively recent origin of engineering as a profession, Mr. Crane stated that the line which has unconsciously been drawn between scientists, as such, and the scientific men, or engineers, who make science practical and its products available to all, has been a cause of friction and retarded the progress of the engineer in reaching a position where the engineering department is considered of equal importance with the departments of production and selling. The former close connection between designing and building has become more or less broken as the manufacturing plants have increased in size and the men in the different departments are often too widely separated. The extreme of specialization has been reached and in some respects its result is inferior to that obtained under former conditions but, as no one man can acquire all the necessary knowledge, it is possible to approach the efficiency of the former methods by taking a broader view of the engineer and engineering and by cooperative effort. The engineer is expected to know foundation principles and the capacity for accuracy for all operations. He should use this knowledge in his original designs and not depend upon the shop for such matters. In this the shop representatives should meet the engineer half-way. The difference between the best and worst factory managers is simply one of viewpoint. It is within the province of the engineer to consider the salability of the product. The engineer is the best judge of what the public should have, because he knows what can be done. The sales viewpoint is for today, but the viewpoint of the engineer should be for at least two years into the future. The engineer must know the past, present and future of the industry and have a knowledge of allied industries. The automobile includes examples of every form of manufacture. The engineer should have also a knowledge of merchandizing. If the engineer grows along the lines indicated he will fill a much larger place than he does today.

In the opinion of Colonel Alden, there has been no time when the position of the engineer was more at the parting of the ways than it is today. The engineer is now fighting the problem of the survival of the fittest. The position of the engineer in the automotive industry will be just what the engineer makes it. Engineering department rating is according to the ability of that engineering department. In just so far as the engineer *serves*, he will progress. Design requires a knowledge of all the steps of production and should include a knowledge of sales, where and how to sell. The value of an individual to an organization depends upon the amount of responsibility that individual is willing to accept. The success of the work of the Society depends upon the quality of its service to the automobile industry.

The viewpoint expressed by Mr. Moskovics was that Mr. Crane and Colonel Alden expect too much of the engineer and that such an engineer as they have in mind would, in reality, be an executive in any given organization. Weighing with due appreciation the technical side of engineering, he considers empirical engineering the most important phase. He believes that all operations must become cooperations and that the cooperation of the engineer with the production department must be through actual contact.

Mr. Beecroft subscribed to the broad conception of what an engineer should be, as stated hereinbefore.

Mr. Utz remarked that the difference between failure and success is largely the difference between dignified acquiescence and cheerful cooperation. He observed that the tendency toward maintaining a close-mouthed attitude, formerly a characteristic of the engineer, is fast disappearing and that the engineer of today realizes better the value of expression and cooperates by giving full explanation of all of his work.

Body Engineering Session

The Body Engineering Session on Wednesday afternoon could hardly have been excelled for display of enthusiasm and interest. All of the hundred or more in attendance expressed the greatest approval of the Society's recognition of this branch of automotive engineering. Papers contributed by Andrew F. Johnson and Kingston Forbes emphasized the importance of the art

of automobile body design and urged future cooperation among the men engaged in the profession. The paper read by George J. Mercer outlined the predicted trend of passenger-car body design for the coming year. The various body types were treated by Mr. Mercer and desirable color schemes suggested.

Charles A. Heergeist, the venerable carriage and body engineer, was present, his paper on the possibility of reducing body weight being read by A. P. Cardwell. This paper aroused an unusual amount of valuable discussion. The use of veneer as a weight-reducing medium has not met with favorable results apparently and it is felt that there is still a considerable field for design study to secure lighter weight.

The chassis and body engineer must cooperate to attain the proper result in this regard. It was the general expression of those present that the body must be heavy to withstand the strains resulting from chassis frames which are not stiff enough. George E. Goddard gave a very interesting description of the production methods employed in manufacturing all-steel bodies in large quantities, illustrating his talk with motion pictures.

In a general discussion after the completion of the program of papers, the body engineers recorded their interest in body standardization. Vice-President W. G. Wall served as chairman and contributed to the general discussion.

Chassis Session

At the technical session on Wednesday afternoon covering chassis design for fuel economy the principal thought in the minds of practically all the speakers was that while high fuel economy had undoubtedly been obtained in Europe, these results were by no means disparaging to American motor cars since in nearly every case the cars tested were either light-weight stock cars of designs that could not be successfully utilized in America or were cars of a size comparable with present-day practice in this country that had been materially lightened by the removal of every piece of surplus equipment. H. M. Crane, who presided, stated in his opening remarks that the public is entitled to speedy, comfortable transportation regardless of the amount of gasoline consumed. The petroleum industry, he said, had inquired about the use of low-geared cars rather than the present type of car equipped with high gears. In his opinion the reason the low-geared car had not come into general use is the fact that the public has demanded a car that will go practically anywhere without necessitating gear-shifting, which as he described it, is at best a difficult operation and in some cases resembles an acrobatic feat. Other points which were emphasized as tending to prevent the securing of more economical use of fuel were a brake adjustment by which the brakes are applied half the time, the engine consequently having to develop power to overcome this resistance, and defective gearbox and rear-axle design which causes poor lubrication due to the fact that the gearbox either does not retain the lubricant or requires the use of heavy grease.

J. G. Vincent compared the demands of economy and performance. He said that gasoline economy is not the only economy in car operation and that the three factors that determine the economy of a car are chassis design, engine design and tires. The demands for performance on the part of the user limit the engine design. Engines, he said, can be grouped into three classes, a small high-speed engine for a gear ratio of 5 or 5½ to 1, the large slow-speed powerplant suitable with a ratio of 3 or 3½ to 1, and the average engine, the proper gear ratio for which is approximately 4 to 1. There is not much difference in economy with any of the three designs. The chassis should be well balanced, special care being given to the ease with which the various necessary adjustments can be made. Great advances have been accomplished in the design of tires, and generally speaking cord tires can be depended upon to give uniform results. The practice of over-sizing tires is one that Colonel Vincent is not in sympathy with. While realizing the necessity for economy in the use of lubricating oil, this he stated cannot be carried far except at the expense of something else, the present fuel giving trouble resulting from crankcase dilution. A well balanced chassis with a smoothly operating gearbox and engine will give the maximum car economy. It was not possible in Colonel Vincent's opinion for the industry to concentrate production on a few sizes of car as the range must be sufficient to meet the demands of the purchasers. One point that is often overlooked in designing a car is the service standpoint. Service, he stated, costs in proportion to simplicity, reliability and accessibility, and all cars have offended in the last respect. The question of making gear-shifting easier is receiving consideration. The four-speed gearbox recommended by some designers is not suitable for the present car but could be incorporated very satisfactorily if the light-weight car so extensively built in Europe were adopted in this country.

A. L. Putnam presented the paper on Chassis Design for Fuel Economy which is printed elsewhere in this issue. He stated that while the engine is the most important part of the complete chassis and is far in advance of the rest of the machine due to the large amount of attention which has been paid to its development, great improvements in engine efficiency are not evident in operating under normal service conditions. He believes that opportunity is afforded the passenger car engineer to make improvements in the automobile as a road vehicle, rather than for the engine designer to improve his product. Among the factors which he emphasized as deserving attention are the use of heavy grease for lubricant, dragging brakes, and the elimination of excessive relative motion of the various parts of the automobile. Another point considered by the author worthy of consideration is the use of pneumatic tires of larger cross-section and the lessening of the air pressures stipulated for their inflation.

In the absence of William T. Magruder, his paper, entitled The Present Need for Researches on Automobiles Other Than on the Engine, was read by C. F. Clarkson. In this paper, which is printed elsewhere in this issue, emphasis was placed upon the fact that greater attention must be paid to the smaller parts and the various appliances found in automotive machinery than has been the case in the past. An outline of some of the tests of automotive machinery and parts that have been made in the mechanical engineering laboratory of the Ohio State University was presented. These covered the friction of the engine at various speeds and with different parts removed, the effect of the temperature of the jacket water upon the power and operation of the engine, the power lost in transmission and the power delivered by the rear wheels. It was hoped that tests to show the relative motions of the body and the chassis might be made shortly. In addition to outlining these tests and the manner in which they were conducted a number of results that had been obtained were incorporated in the paper.

W. P. Kennedy read a letter which had been received

by Col. A. J. Slade from the Motor Transport Depot of the U. S. Quartermaster Corps regarding the German light passenger cars that had been brought to this country. One of these cars has been rebuilt and used in courier service averaging about 110 miles daily and it was planned to do the same with a second one. The tests which have been conducted indicate that a small passenger car is more reliable for mail courier service and more economical to maintain than the heavy motorcycle with sidecar. It was believed that if further tests indicated that the light-weight car would be successful, the tread should be increased to make it conform to American practice and the general design changed to render the various units more accessible, the present design making repair work on any of the units very difficult.

Two papers were presented at this session which were not closely related to the fuel economy phase of chassis design. One of these dealt with Torsional Strength of Multiple-Splined Shafts and is printed elsewhere in this issue. In presenting the paper the author, C. W. Spicer, described a number of test which had been conducted by his company. These showed that a splined shaft has a torsional elastic limit of approximately 18 per cent less than a full round shaft of a diameter equal to the small diameter of the splined shaft. This is directly opposed to the conclusion which would be obtained superficially that the torsional strength of the multiple-splined shaft is greater than that of a full round shaft. The other paper by S. E. Slocum which dealt with a Principle of Engine Suspension, was printed in the January issue of THE JOURNAL. It describes an application of the three-point principle of support for automotive apparatus, the main object being to relieve the chassis of the vibration transmitted to it by the engine, some of the effect of vibration on the chassis being loss of power and fatigue of the metal employed. The vibrations Mr. Slocum stated are most noticeable with the closed type of body. While the three-point suspension of the engine was discussed at some length in the paper, the author stated that numerous other applications of the principle are feasible.

John G. Perrin described the results of some investigations he had made of the use of light cars abroad. In his opinion it is not possible to learn very much from these foreign cars; and there is nothing radical in their design. While these small light-weight cars are economical in the use of fuel, they would not be suitable for this country unless it should be possible to do away with the idea of purchasers here that a car should go anywhere on high gear. The engines are chiefly of the I-head type. The pockets in the combustion-chamber are small. The carbureters are practically the same as those employed in this country. The use of small cars made light weight possible. The large European cars are practically the same as those designed in the United States. The roads abroad are on the whole better than those in this country and the possibility of using the direct drive for long periods of time gives better engine economy. The Ricardo engine, the speaker stated, is the only new feature of design. This engine, which was used in British tanks during the war and is now employed in the Siddeley car, has a long trunk piston, one section acting as a guide for the other which functions as a regular piston. The use of a short piston-rod which is prevalent in this country adds to the losses due to piston friction. The British are paying attention particularly to the small cars with narrow tracks and small clearances which could not be used in this country, the engines averaging 11 to 12 hp. Two other factors which help to secure apparent high fuel economy abroad are a better grade of gasoline and the use of the Imperial gallon which is approximately 20 per cent larger than the standard United States gallon. The high-priced cars incorporate airplane features such as the use of the aluminum engine with steel sleeves, two noteworthy examples being the Hispano-Suiza and the Napier powerplants. In conclusion Mr. Perrin stated that the designers in this country are much nearer a solution of the fuel economy problem than their foreign brethren are.

In the discussion which followed the presentation of these papers it was pointed out by several of the speakers that while it is possible to get greater mileage from a gallon of gasoline abroad than in the United States, this is due largely to the lighter weight of the cars undergoing test and that if a comparison on the basis of the number of ton-miles secured from a gallon of fuel were made it would be found that the results secured in America are creditable. One of the speakers mentioned a test of the Petit Peugot car with which a 70-mile run was made at an average rate of 28 m.p.h. and 30 miles was secured from a gallon of gasoline. In commenting on the French test figures F. E. Watts stated that the French fuel economy tests did not give proper credit to the American cars and that nothing is being done abroad toward securing higher fuel economy that is not being done in this country. C. T. Myers also spoke of conditions surrounding the French fuel economy tests, stating that everything possible was done to secure the maximum ton-mileage, the stripping of the car to secure this result being carried to a point where equipment that is considered essential on American cars was removed. O. C. Berry stated that a French car weighing 5500 lb. has been driven 23.8 miles on a gallon of gasoline, while the average for the six-cylinder American car weighing 3000 lb. is 15 miles and that 20 miles is an excellent performance. There is nothing new, he said, in the English, French, Italian, and German cars which is responsible for high fuel economy and in fact in tests in this country as high as 40 miles per gallon has been obtained. He stated that properly run economy tests have a definite value and should be held yearly under the control of an engineering body. If this were done, the performance requirements being set before the tests were made, the results would have significance. At the present time the fuel situation limits the automotive industry.

H. L. Horning described some tests that had been made of an engine in which the mechanical efficiency was increased from 80 to 92 per cent by changing the grade of oil. If the horsepower required to overcome friction in an engine is to be reduced, attention must be given, he said, to improving piston design, since the friction between the piston and the cylinder walls is responsible for 50 per cent of the power lost in overcoming friction. He said also that pressures as high as 10,000 lb. per sq. in. are developed on the oil film between the piston and the cylinder walls.

COMMERCIAL AVIATION SESSION

Vice-President Glenn L. Martin, who was chairman of the Commercial Aviation Session, presented a most instructive paper on Commercial Aerial Transportation. He stated that its success depends upon the operative personnel, the airworthiness of the craft and weather conditions. As evidence of commercial practicability, mention was made of the success attained already in expediting delivery in the United States mail service, Mr. Martin reviewed the service already given by the 17 airplanes

now in use in the Forestry Department. The need for aerial terminals was emphasized and the benefits that a town or city derives from being located on an air route were described. It was stated that Federal regulation is the only solution of making commercial aerial transportation a success.

The matter of aircraft insurance was discussed and the basis upon which premiums can be figured was said to be dependent upon the capability of the pilot, the efficiency of the aircraft and the type of engine employed. Mr. Martin commented upon the present conservative attitude of the Government, and averred that commercial aviation is here, and must be developed and popular prejudice and skepticism overcome.

Prof. E. P. Warner's paper on Commercial Aviation in Europe was illuminative and afforded an opportunity for better comprehension of the remarkable progress and accomplishment made there in commercial lines. Reviewing the present European routes now in regular or partial operation, he stressed the essentialness of the attitude of the press in general being favorable if commercial aviation is to become wholly successful.

The airship appears most practical for long-distance service to Professor Warner, and he mentioned the possibility of cities and towns growing up around "air ports." The cost of airship travel was specified as 15 cents per mile, or less, although it is difficult to figure costs and necessary charges because so few data on depreciation of equipment are available.

Regarding successful operation, much depends upon the efficiency of the ground personnel and organization. It is present practice to send out to aviation pilots by radio telegraph hourly weather warnings which give the height of the clouds, the degree of fog at ground level and details of visibility.

Following a discussion of the matter of Governmental subsidies, Professor Warner described the different kinds of machines and stated many of the advantages and disadvantages of single and multi-engined aircraft, his opinion being that multi-engined machines are necessary, especially for extremely large units. Slides were then shown of the different types of airplane now in commercial use.

In the discussion which followed, R. H. Upson insisted upon the necessity of cooperation between the operative and manufacturing departments of aviation; Ladislas d'Orcy stated further considerations in regard to Governmental subsidies; and E. A. Sperry gave interesting data on the penetrating power of beams from searchlights as applied to guiding air pilots to landing fields and terminals.

The Aerial Transportation of the Immediate Future was comprehensively considered by Ralph H. Upson in presenting his paper on this subject. He gave an outline of the fundamentals and divided the subject into a discussion of what we have at present and what must be considered for the future, stating that it must be left to the inventors as to how far they can go in providing equipment. The first question regarding new equipment is, "Will it work?" The next, "Is it safe?" Safety was described as being purely relative and the statement made that there is no such thing as absolute safety. There is no need to expect danger. We must have both speed and safety and making aerial equipment safe is well worth while, no matter at what expense of money and effort. As to whether commercial aviation can be made to pay, economically and so far as society as a whole is concerned, this is comparatively a relative question and depends upon the length of haul and the mileage cost. Charts were shown and methods of obtaining basic costs described, together with formulas and coefficients so obtained. These were worked out for both airplanes and airships. Other charts giving the yearly operating costs of airships, their capital expense and cost curves, and the size of airships required for given distances of cruising radius were shown and explained. The speed and cost data for cargo of varying time value carried over various distances, and the cost of freight transportation, were presented in additional charts.

In the discussion which followed, the merits of the airship and those of the airplane were compared. Professor Warner enumerated the main requirements for successful aerial transportation at night.

L. B. Lent, of the United States Air Mail Service, gave a résumé of the performance attained in American regular aerial mail service lines and stated that the only excuse for multi-engined airplanes is to enable them to travel from terminal to terminal without the necessity of forced landing. For this, his opinion is, from one to three engines are needed. Maintenance and repair costs are heavy items and merit careful consideration. The work of the Society can best be devoted to clearing up airplane design and making airplanes more reliable. Commercial aviation is a real practical proposition, but greater ability to fly above the clouds and to locate terminals is needed and for this it is necessary that aerial navigation instruments be improved and additional ones provided.

The paper presented by S. W. Sparrow gave in succinct form the Relation Between the Compression Ratio and the Thermal Efficiency of an Airplane Engine, the result of an investigation by the Bureau of Standards which was sponsored by the National Advisory Committee for Aeronautics. Every effort was made in this investigation to measure the engine performance so completely as to make possible an analysis explaining not only the results of this series of tests, but forming also a sound basis for predicting the effect of changes in compression ratio on the thermal efficiency of any engine. The experimental work has not been completed, but the more salient results were presented.

The tests for which an eight-cylinder airplane engine was used, were made in the altitude chamber of the dynamometer laboratory in order that typical altitude conditions of air temperature and pressure might be obtained. The data reported were secured at full load, at an engine speed of 1600 r.p.m. The paper includes considerable technical detail, the results being given in various charts and summaries that should be considered in relation to each other for thorough comprehension. It is planned to publish the paper in full in an early issue of THE JOURNAL. One point brought out is that the gain ensuing from the employment of the higher compression ratios increases with increase in altitude. This latter effect is due solely to the increase in power and the resulting smaller ratio of friction to brake-horsepower. Hence, the same condition would result from supercharging or from any other method of efficiently increasing the power developed. The fuel used in these tests was aviation gasoline.

Following Mr. Sparrow's paper, it was stated that the Bureau of Civil Affairs, at Washington, has plans for airdromes, layout and the like, and is desirous of cooperating fully with the Society in matters relating to aircraft development and operation. It was announced also that the National Advisory Committee for Aero-

nautics has prepared a tentative program for a contest in the interest of commercial aviation which it is hoped will materialize. An airway between Washington and Dayton, Ohio, has been proposed, equipped with hangars and necessary material that will permit flying at night, and over which an inexperienced pilot can make his way in one day.

Fuel Session

The intense interest of the members in this feature of the Annual Meeting of the Society, held Jan. 13, 1921, was manifest throughout its continuance by the large attendance at both the morning and afternoon sessions, by the close attention paid the speakers during the presentation of their excellent and comprehensive papers and by the spirited discussion which followed.

President Vincent was chairman at both sessions. At the opening of the morning session he made some very pertinent remarks relative to the fuel situation in general and to the necessity of active cooperation with the oil industry in the solving of the fuel problem. Following his remarks, he called upon Charles F. Kettering to present the subject of Fuel Research Developments.

Mr. Kettering first referred to the remarkable progress in fuel research work during the past year and then stated that there is a "dead-line" in the utilization of fuel in internal-combustion engines beyond which progress cannot be made. The automotive industry must cooperate with the oil industry and find out what and where this dead-line is; it must know the end-point of fuels obtainable five years hence.

The two distinct divisions of the fuel problem are the fuel distribution in multi-cylinder engines and the chemical changes that occur inside an engine cylinder during combustion. Considering and explaining an elementary case, that of the combustion of hydrogen and oxygen, the components of combustion energy were stated to be gravitational, kinetic and barometric, and these, in turn, were considered and analyzed in considerable detail, with the aid of charts, formulas and diagrams illustrative of molecular structure. Other charts showed the normal combustion of propane, its abnormal combustion such as occurs during knocking and the method of calculating the knocking value of a fuel.

In Mr. Kettering's opinion, regarding any theory, the greatest difficulty is to obtain a proper conception of the terms employed in its development and to apply this knowledge correctly. This idea was amplified and the strange fact that substances of apparently diverse composition are in reality made up of the same chemical constituents was illustrated by several exhibits of substances that have been chemically analyzed. That engineers must think of heat in terms of molecular velocity was emphasized and it was stated that the proper fuel mixture for an internal-combustion engine is not dependent upon the molecular construction of the fuel.

Engine friction is one of the most difficult problems with which an engineer must deal and it must be reduced in some manner. The present need is to burn less fuel per car-mile. Numerous slides of indicator cards obtained when using the different available fuels in an internal-combustion engine were exhibited and the different characteristics of the performance of each fuel explained.

Previous to calling upon Frank A. Howard to present his paper on the Volatility of Internal-Combustion Engine Gasoline, President Vincent remarked that the fact that nothing went wrong in the performance of the single-cylinder Liberty engine, with which he is so intimately connected, indicates that a large portion of the difficulties experienced at present is caused by poor distribution of the fuel to the various cylinders in a multi-cylinder engine. Mr. Howard then presented his paper.

After stating that the meaning of the term "gasoline" seems to be generally misunderstood for the reason that it has been assumed that gasoline is, or ought to be, the name of a specific product, Mr. Howard said that it is not and never has been a specific product and that although gasoline has a definite and generic meaning in the oil trade it has no specific meaning whatever. It means merely a light distillate from crude petroleum. Its degree of lightness, from what petroleum it is distilled and how it is distilled or refined are unspecified.

Specifically, "gasoline" is the particular grade of gasoline which at a given moment is distributed in bulk at retail. It can be defined with reasonable precision as being the cheapest petroleum product acceptable for universal use as a fuel in the prevailing type of internal-combustion engine. The author placed emphasis on the three factors of this definition: (*a*) the cheapest product, (*b*) its universal use and (*c*) the prevailing type of internal-combustion engine.

Mr. Howard's purpose in this paper is to clear away some of the haze which surrounds the word "gasoline" and, with regard to what volatility is with reference to engine gasoline to show how much of the difficulty is inherent in the fuel and how much of it arises from the failure of automotive engineers, collectively, to attain a high average of perfection in the handling of the fuel.

Ordinary engine gasoline of the grade now sold possesses sufficient inherent volatility to take and maintain the condition of a gas at a temperature at or below average intake-manifold temperatures. Manifold condensation seldom, if ever, occurs and cylinder condensation is even less probable. The phenomena answering to these names are in fact mainly the visual evidences of the failure of the vaporizing device to function. Fuel once vaporized must stay in that condition; hence, if liquid is found beyond the vaporizer, it reached there as a liquid.

These conclusions are based on an examination of the fuel itself. The volumetric proportions of a combustible mixture are considered in detail in this paper and the physical meaning and measurement of volatility are fully discussed, tables of vapor tensions being given and the special apparatus developed to determine the vapor tension of gasoline being exhibited and described. Following this a full discussion of the requirements for full utilization of inherent volatility is presented, the conclusion reached being that the problem resolves itself into the further development, improvement and wider use of the hot-spot.

The next paper presented was that of C. A. Woodbury, the subject being the Nature of Flame Propagation in a Closed Engine Cylinder. The possibilities with regard to suppressing knock in an internal-combustion engine cylinder were discussed. The photographic method was used to study flame propagation. Gas was exploded in a cylinder of constant volume which had no piston and the photographs were made through a glass window. A photographic diagram of the apparatus was shown and explained and a table giving the velocity of the flame movement for various mixtures of acetylene and air was presented. Numerous photographs of the flame movement of different fuels were then shown and commented upon.

The difficulty of producing detonation in a small combustion-chamber was mentioned and the statement was made that the tendency to detonate is not increased by an increase of temperature.

At the afternoon session, the first paper was presented by Reuben E. Fielder, entitled Air-Temperature Regulation Effects on Fuel Economy.

In connection with the present fuel shortage, the problem of securing a much higher degree of economy with existing equipment and that of future design are of nearly equal importance. The fuel bill of the Fifth Avenue Coach Co., New York City, constitutes its second greatest item of expense, and for this and many other reasons this company is constantly experimenting with devices of various kinds to improve fuel economy. Its present thermostatic temperature control for the carbureter appears to afford greater possibilities of fuel saving than anything else that has been brought to its attention and Mr. Fielder presented the results of tests of this device.

A diagram of the device was shown and explained and a detailed description given of the thermostat. Comparative tests were made with and without this thermostatic-control device, using the same engine, carbureter and similar equipment, under the same conditions of atmospheric temperature. The results were summarized and illustrated in the tables and charts that were exhibited.

The effect of atmospheric temperature variations was studied in connection with comparative fuel distillation curves, with reference especially to the effect of variation in manifold temperature on fuel economy and torque developed, in an effort to obtain data as to what constitutes a desirable manifold temperature. The necessity of considering the important matter of volumetric efficiency is evidenced by the gain of the thermostatically controlled equipment over the standard equipment, much of this gain being due to an increase in volumetric efficiency with the cooler air.

The company believes that the principle of thermostatic temperature control is correct, but that its detailed application is still a matter for further experiment. At certain periods of each year the average internal-combustion engine functions with the minimum amount of trouble, because at such times the atmospheric temperature is right. The idea is to select such a period and to standardize it for use throughout the remainder of the year.

A. L. Nelson presented an unusually interesting and comprehensive paper on the Fuel Problem in Relation to Engineering Viewpoint. He stated that it is believed that never before in the history of the Society of Automotive Engineers has a single problem been so universally studied as the fuel problem that is confronting the industry today. It is also believed that never before has the industry had a problem which includes such a wide scope of work. The solution calls for the service of every class of engineer, inventor and scientist.

The paper does not attempt to give highly scientific information; its real purpose is to appeal for a broader viewpoint and give illustrations and tests which show that the solution of a problem may lie in an entirely different method than that which often becomes stereotyped by sheer usage, rather than by its specific merit. In the solution of the fuel problem we undoubtedly will have to change some of our old habits, replacing them by studiously worked out viewpoints. The further object of the paper is to seek the correlation of the experience of the entire engineering fraternity, to obtain the comments of its members and receive any suggestions they may offer.

After giving recognition to the cooperation and assistance already received and making general comments upon the desirability of radical changes in viewpoint, Mr. Nelson entered upon a discussion of the engine power required to drive a car at constant speed and the effect of using higher piston compression ratios, illustrated by a table and charts, with a view to demonstrating the value of modified viewpoint. In like manner he discussed the constant-clearance aluminum piston and the fuel vaporizer. The basic principles of the engine used in testing were next considered and copiously illustrated, together with the apparatus used in the dynamometer and practical driving tests that were made. Charts show the percentage comparison of results and these are explained.

After a discussion of ideal economy, it is stated that the tests show that an absurd waste is rampant in the present method of applying the indicated engine power and that this subject should be studied from every angle. A close study from the brake-horsepower standpoint may justify changing both transmission and rear-axle drive ratios. The latter combinations, together with engine developments, look the most promising at present. The progress we make will be measured by the extent to which we expand our engineering viewpoint.

Dr. H. C. Dickinson gave a résumé of the fuel study made by the Bureau of Standards. In connection with the effect of compression on a dry mixture, curves were shown to illustrate that gasoline vapor compresses when "dry." Detonation was evident when using one spark-plug and there was no detonation when using two spark-plugs. After preliminary experiments of the nature already indicated, a pressure indicator was used, at pressures just on the verge of detonation, to find the exact point where detonation occurs. Slides were exhibited to show the position of the piston with reference to its center position, with one spark-plug and with two spark-plugs; and the effect of spark advance on maximum explosion pressure and brake-horsepower, using one spark-plug.

The Discussion

The discussion which followed the presentation of the fuel session papers included comment by many members on the debatable points that had been raised. It is expected that this discussion will be printed in full in an early issue of The Journal, but its trend can be indicated by quoting briefly some of the important ideas expressed.

Among these was the belief of L. M. Woolson that, in place of needing a change in viewpoint such as was advocated by A. L. Nelson, the necessity is for closer concentration on the detail problems of the automotive industry. He stated that it is perfectly possible to reduce the gasoline consumption of 1.125 lb. per b.hp-hr. at 1000 r.p.m., attained by Mr. Nelson in one test, to about 0.93 lb. per b.hp-hr., which represents a gain of something like 20 per cent in gasoline mileage, by constructing carbureters that will give a lean mixture under average driving conditions, and that this can be done without diminishing acceleration or wide-open pulling ability.

Regarding fuel vaporization, Mr. Woolson's opinion is that the ability to accelerate well in cold weather without pulling the choker soon after starting does not prove that sufficient heat has been furnished to the mixture under average driving conditions, and that it would depend upon how rich a mixture the carbureter was set to furnish at the time. He believes that actual intake mixture

temperatures should be referred to in discussing methods of fuel vaporization, instead of referring to car performance in a general way or to other less specific data. There is a certain desirable range of mixture temperatures which probably will apply to all engines under the same conditions and automotive engineers need to know what that temperature range is. He believes that the desirable temperatures will be found to be about 100 deg. fahr. above those obtaining in the average intake-manifold. He believes also that there will be considerable variation in future opinions as to the significance of actual manifold temperature measurements and concurs with F. A. Howard in the opinion that it is not desirable to heat the air unduly but that it is necessary to apply fairly high temperatures to the fuel. In one case there may be an average mixture temperature of 120 deg. fahr. and a relatively poor degree of vaporization, and in another case, with the same average temperature, almost complete vaporization. Mr. Woolson thinks that the next step must be to determine the best average mixture temperatures under different conditions and believes the suggestion of H. L. Horning that these should be determined in terms of carbureter efficiency is really constructive.

Herbert Chase urged consideration of the work of A. L. Nelson toward obtaining better fuel economy under part-load conditions, recommending that this procedure be developed further because most efforts in this general direction are made under full load. He stated also that the average car wastes about 30 per cent of the fuel that is supplied to it and that automotive engineers should be able to prevent a large part of this waste.

The direct question was asked by J. D. Gill, a representative of the oil refining industry, as to what the automotive industry specifically wants as fuel for internal-combustion engines. He called attention to the possibility that detonation is due to a lack of the requisite amount of fuel in some certain cylinder in a multi-cylinder engine and suggested the introduction of a fuel reservoir in which pressure can be built up, in a similar manner to that used in water-flow systems, thus furnishing continuous fuel flow with carbureter pulsations practically eliminated.

F. A. Howard mentioned that successful fuel economy results appear to depend upon the juggling of the three factors, surface, time and heat.

A study of the carbon monoxide content of internal-combustion engine exhaust gases by the Bureau of Mines, as the result of tests of about 100 automotive vehicles, in connection with the adequate ventilation of the vehicular tunnel now being constructed under the Hudson River between New Jersey and New York, was presented by A. C. Fieldner and slides were shown of the apparatus used and the curves and values obtained from test results. The chemical control of exhaust gases and carbureter settings was advocated. In connection with exhaust gas content, E. A. Sperry stated that no trace of carbon monoxide had been found in the exhaust gases of the Diesel engines in use at the United States Navy Yards.

The subject of the design of pistons, piston-rings and grooves, with special reference to proper shape for racing-car pistons, the desirable location for piston ribs and allowances for expansion, was discussed by William C. Davids.

T. C. Menges stated his experience in running stationary engines on kerosene, they being equipped with a throttling governor, a high-tension magneto and a spark-plug in place of the ordinary make-and-break. The great difficulty has been to run such an engine successfully with a light load or with no load. He advocates locating the carbureter above the inlet valve of the engine; in this position not as hot a manifold and not as hot an intake of air are required, better volumetric efficiency is obtained and the engine runs more satisfactorily. The inlet manifold should be short, with few bends. Mr. Menges has been able to run these engines on kerosene without a hot-air manifold and has not had to use water to reduce knocking, probably because the vapor enters the engine fairly cool. The fuel nozzle should be located next to the edge of the butterfly throttle-valve in place of being a long distance from it as is the case with most automobile carbureters. If so located, the butterfly throttle-valve is almost closed when the engine is running with no load. The small amount of air that passes into the carbureter must pass the fuel nozzle; this breaks up the liquid fuel and forms an explosive mixture. Mr. Menges believes that if the liquid kerosene could be broken up into a fine enough mist, an engine would start cold on kerosene. On the contrary, if the kerosene is not thoroughly broken up, an excess amount of heat will be required to vaporize it.

H. L. Horning said that the proposed program of co-operation between the Society and the American Petroleum Institute comprised the four stages of gathering, classifying, analyzing and using the data available, that a large portion of the first two stages had now been covered and that what is needed at present is to go more deeply into the work of the third and fourth stages.

Stating that the matter of carbureter efficiency had been obscured, he exhibited and explained charts and formulas illustrative of his beliefs, especially to the effect that indicated mean effective pressure is the net return for whatever energy may have been expended, and showed the derivation of a formula for determining what he terms "gasification efficiency."

Regarding flame propagation, his theory is that of maximum area and he believes that the consumption of a certain volume of fuel within a minimum length of time should not be attempted.

Highway Session

At the Highway Session held Wednesday afternoon Past-President H. W. Alden presided. His opening remarks on Automotive Obligations Toward Highway Development are printed elsewhere in this issue. In this address Colonel Alden emphasized the fact that the automotive industry is responsible for other things than the actual building and selling of motor cars and pointed out that the correct solution and proper arrangement of railroads, highways and waterways in the general function of merchandise transportation will have a wonderful effect on the future of the entire automotive industry. The railroads are at the present time doing a great amount of less-than-carload short-haulage work, for which they are not so well equipped as is the motor truck, with the result that freight cars average little better than 25 miles per day, due to this fact and terminal delays.

The first paper of the session was by W. E. Williams on Highway Construction. In presenting the paper, which is printed elsewhere in this issue, Mr. Williams took up the three types of road, which are brick, asphalt and concrete, and discussed their various defects. In the brick road the most prominent defects are the variation in height of the bricks and the bond between them, which results in the corners breaking down in service from the effect of the toe calks of the horses and the steel tires of the vehicles which they draw. This variation in

the road and also the racing of the gears which follows the dropping of the wheel into a depression in the roadbed, produces a jarring effect upon the vehicles; accordingly vehicle owners should object to the use of brick. Another objection to a brick road laid on a concrete foundation is that such a road costs more than a concrete slab of the same total depth and the beam strength necessary in a road surface to distribute the load is limited in a brick road by the thickness of the concrete sub-base. For example, in a road made up of 6 in. of brick laid on a 4-in. concrete sub-base the beam strength is as the square of the depth of the brick or 36, while if a concrete road having the same depth as the concrete sub-base with a brick top, or 10 in., were used, the beam strength would be 100, or approximately three times as much. The real factor of construction of a road is not the surface but the soil. The asphalt road has merit for horse-drawn vehicles but possesses the same beam-strength weakness as a brick road and also costs more to lay than a concrete road of similar depth. Under traffic this road assumes a wavy surface and the hammer-blow, which term Mr. Williams preferred to impact, produced by the vehicle falling from the crest of one of the waves into the valley destroys the sub-base and thus leads ultimately to the destruction of the road. Asphalt should not be considered, particularly with soils subject to moisture.

A. T. Goldbeck spoke on Government Highway Research. He specified the subgrade as the important factor in road building. There are three types of road failure; that produced by the horse-drawn vehicles which affect the surface only, the raveling action of the surface caused by rapidly moving automobiles, and the structural failure in which both the subgrade and the surface are affected. The various researches which the Government is conducting in the subgrade fundamentals and impact tests, and the way in which they are conducted were explained. In Mr. Goldbeck's opinion it is desirable to decrease the load per wheel but still carry the same gross load as has been carried with steam locomotives. The result greatly desired is that giving the least cost of the motor truck and of the building and maintenance of the road. In conclusion Mr. Goldbeck urged cooperation between the Society and the highway engineers.

H. E. Breed was the next speaker, his topic being Variable Factors in Highway Design. There are, he said, two factors in transportation, the vehicle and the road; and in case of trouble each blames the other, the roads stating that they failed because the vehicles pounded them too hard and the vehicles replying that they are impeded because the roads will not sustain them. To solve the problem the mutual dependence of both factors must be realized. In designing a road the first thing to be specified is the type of pavement to be laid and this is really determined by the volume and character of the traffic which will use the road, although cost, soil conditions, availability of materials and other considerations influence the decision. The greatest damage is done to roads by impact, that is by the pounding of the load upon the road, and this is accentuated by any unevenness in the road or in the tire of the vehicle. Part of the tire trouble is due to carelessness of motor-truck users, although it was pointed out that even if the motor-truck user were educated not to overload his truck beyond its capacity, it would be necessary to supply smooth broad tires that would reduce the damage from impact and also distribute the weight of the load over the road surface. The stability of the soil determines the strength of the foundation used and this stability varies inversely with the moisture content. Surfacing and maintenance are two other variables that require consideration. Special emphasis was put upon the fact that to have a good system of roads it is necessary that politics be divorced from State Highway Departments.

In opening the discussion A. F. Masury described apparatus that has been developed by the International Motor Co. for measuring the effect of inequalities in the road surface on the trucks, illustrating his remarks with slides of the apparatus and also the records which were made on a continuous sheet of paper.

S. W. Williams of the Federal Highway Council emphasized the desirability of having organizations such as the Society, the American Automobile Association and the National Automobile Chamber of Commerce cooperate in an effort to overcome the difficulties and handicaps in the successful development of a highway system which existed at the present time. In his opinion the highway should be fitted to the vehicles that pass over it, rather than limit the vehicle by the character of the highways that are built. In this connection he brought out the point that it is not possible to develop either a highway or a vehicle 5 or 10 years in advance. The highways have an earning capacity and transportation needs will be the factor governing road and vehicle development. The term "drainage," he thought, is misused, the necessity being to keep moisture out of the road, not to take it out after it has gotten in. If the roads were thoroughly dry, practically any weight could be sustained and all talk about limiting the size of trucks would disappear.

A representative of one of the asphalt companies took exception to W. E. Williams' condemnation of asphalt as a road material, stating that his remarks were not borne out by the service record of asphalt on both rigid and non-rigid bases. He also cited instances of the laying of an asphalt wearing course over a road that had been broken down by heavy motor-truck traffic, having salvaged the road at a comparatively low cost.

Social Features

To describe the Carnival of 1921 with the adjectives usually prevalent in the average engineer's vocabulary must be acknowledged impossible. One would have to be endowed with the versatility of a theatrical press agent or the cunning of P. T. Barnum to do it justice. The large ballroom of the Hotel Astor was temporarily transformed into a Parisian boulevard with its colorful sidewalk cafés where food and drinks (typically American) were available. A fashion show with Broadway manikins was arranged for the ladies and appreciated by them and the men. A staged argument between two waiters which ended in a duel was nearly ruined by Harry Horning who wondered what it was all about. The dance orchestra apparently pleased, for they repeatedly begged the devotees of the fox-trot for rest periods, and were not allowed their freedom until 3 a. m. To say that the S.A.E. ladies smiled, danced, and dressed suitably means that they reached perfection. The folk dances rendered by accomplished artists were dainty and pleasing.

The Carnival Committee headed by H. G. McComb accomplished a most successful result and are to be congratulated. The arrangements for an event like the Carnival require weeks of work and thought and the Committee always gave their time unreservedely. The Astor Ballroom was transformed under Mr. McComb's direction for the entertainment and pleasure of the members in a manner never equalled for novelty, effectiveness and beauty.

The Officers of the Society

AT the Annual Meeting of the Society held last month, a President, a First Vice-President, five Second Vice-Presidents and two Councilors were elected and the Treasurer was reelected. In addition to these officers the three Councilors elected at the 1920 Annual Meeting and the last Past-President are voting members of the Council for 1921. To fill the vacancy caused by the election of only two Councilors instead of three as authorized by the Constitution, Glenn L. Martin was chosen by the Council. The careers of the men who will guide the work of the Society this year are outlined in the following paragraphs.

David Beecroft

President Beecroft was born in 1875 at Marnock, Ont., Canada. In 1893 he was a teacher at a country school. Prior to that time he attended the Barrie Collegiate Institute. Beginning in 1895, he was an instructor for six years at a St. Thomas, Ont., school, being connected also with the editorial department of the *St. Thomas Daily Times*. Leaving St. Thomas in the summer of 1901, he was engaged by the *Chicago Daily News* as an advertising solicitor.

In 1902 he became editor of the *Automobile Review*, which had been issued monthly in Chicago. It was changed at once to a weekly. In 1904 Mr. Beecroft was assistant editor of *Motor Age*, with which he has been connected in various capacities since that time. In July 1911, he undertook, in addition to the *Motor Age* work, the position of managing editor of *The Automobile*. In November of that year he became also managing editor of *Commercial Vehicle*, and in February, 1914, he took a similar position with *Motor World*. At the present time he is directing editor of the Class Journal Co., New York City.

Since entering the automobile industry Mr. Beecroft has been particularly active in automobile contest work. He drafted the first stock-car racing rules. He has been closely identified with the American Automobile Association Contest Board for many years.

Mr. Beecroft became a member of the Society in 1911 and has served on the Council for four years. He has been a member of the Meetings Committee for five years and chairman for four years.

H. L. Horning

First Vice-President Horning secured his early training in the modern classical course in Carroll College Academy and the scientific course at Carroll College, both at Waukesha, Wis. In 1901 he was in the chemical laboratory and operating department of the Milwaukee Gas Light Co., and later served for two years in the steam engineering department of the Crane Co. From 1904 to 1906 he was head of the mechanical engineering department of the Modern Steel Structural Co., his most important work at that time being the construction and mechanical operation of the Duluth steel bridge, one of three structures of the kind in the world. In 1906 he established the Waukesha Motor Co.; he has served as its chief engineer and general manager since that time.

Mr. Horning is a member of the American Society of Mechanical Engineers, and of the Association for the Advancement of Science. He was elected a member of the Society of Automobile Engineers in 1910 and through his connection with the Society of Tractor Engineers and the National Gas Engine Association was active in the movement which resulted in changing the name of the Society to Society of Automotive Engineers.

He was chairman of the automotive products section of the War Industries Board, Council of National Defense, during the war. He served as Chairman of the Design Committee of Engineers that laid out the engines for the Class B and AA military trucks. He was the first chairman of the Tractor Division of the S. A. E. Standards Committee and was a member of the first Oil and Fuel Committee established by the Council of the Society.

Truck and Tractor Engines was the subject of a paper he presented in 1916 at a Mid-West Section meeting. At the 1917 Annual Meeting he presented a paper on the Ultimate Type of Tractor Engine and at the 1917 Semi-Annual Meeting gave a paper on the Farm Tractor as Related to the Food Problem. He also presented a paper on Tractor Engines and Fuel Limitations before the Detroit Section in 1919.

As a representative of the Society Mr. Horning accompanied the National Screw Thread Commission on its trip abroad during July, 1919, to make a study of foreign screw-thread practice. Together with Dr. Dickinson of the Bureau of Standards he visited Dr. Dixon of Manchester University and brought back to this country a statement of the theory of engine knock and detonation.

He proposed and aided in the movement to bring the automotive and the petroleum industries together for the purpose of dealing promptly with the fuel question. Mr. Horning was chairman of the Committee on Utilization of Present Fuels in Present Engines, whose first report was presented at the meeting of the Society held last summer. He also proposed the plan of inviting leading internal-combustion engineers of Europe to visit this country to take part in meetings of the Society.

B. B. Bachman

Second Vice-President Bachman, representing motorcar engineering, was born Oct. 4, 1886, educated at grammar school, night school and under a private tutor, and started his business experience in 1900 as a tracer. The next 10 years were spent as tracer, detailer and designer with the Enterprise Mfg. Co., and the Falkenau Sinclair Machine Tool Co., both of Philadelphia, and the Autocar Co., Ardmore, Pa. His entire automobile experience has been with the last named company, which was a builder of passenger vehicles until 1912 and of commercial vehicles from 1907 to date. Starting with this company in February, 1905, he became assistant engineer in 1909 and engineer in 1914.

He was elected a Junior Member of the Society in 1910 and transferred to Member grade in 1912. Mr. Bachman is a member of the American Society of Mechanical Engineers, American Society for Testing Materials and the Institution of Automobile Engineers. When the Pennsylvania Section was organized he was one of the charter members and served as its first secretary. He was identified with the work of the Truck Standards Division in 1911 and has been Chairman of the Standards Committee since 1918. At present he is a representative of the Society on the American Engineer-

DAVID BEECROFT

ing Standards Committee. He was elected to the Council in 1916 and again in 1918. In 1919 he was elected First Vice-President of the Society. As a member of the Truck Standards Division Mr. Bachman participated in the formulation of the specifications for military trucks for the Quartermaster Department, and afterwards was engaged at irregular intervals in the design of Class B and Class A military trucks. In the design of the Class A Military Truck, he was chairman of the committe on design.

At the 1913 Annual Meeting Mr. Bachman presented a paper entitled Comparative Results with Solid and Pneumatic Tires on Light Commercial Vehicles, and at the 1914 Annual Meeting he treated the subject of Double-Reduction Live Axle. At the 1919 Motor Truck Meeting he gave an address on Pneumatic Tires for Trucks.

E. A. Johnston

Second Vice-President Johnston, representing tractor engineering, was born at Brockport, N. Y., Aug. 1, 1875. After receiving a public school education he entered the Chicago Business College. From 1890 until 1894 he was employed by the Johnston Harvester Co., Batavia, N. Y., serving in all departments including wood and metal pattern-making, blacksmithing, machine shop and foundry. In 1894 he accepted a position as pattern-maker with the McCormick Harvester Co., and has been continuously employed by its successor, the International Harvester Co. and its subsidiary organizations as machinist, designer, experimental engineer, foreman, superintendent and manager of the experimental department. He now holds the position of manager of the experimental and gas power engineering departments.

Mr. Johnston is the chairman of the Tractor Division of the Standards Committee. He has had a very wide experience in electrical and mechanical engineering and research work related thereto. He was elected a Councilor at the 1919 Annual Meeting.

Henry M. Crane

Second Vice-President Crane, representing aeronautic engineering, was born on June 16, 1874. He received his education in private schools with a final year at Phillips Exeter Academy, graduating in 1891. He was graduated from Massachusetts Institute of Technology in 1895 with the degree of Bachelor of Science in Mechanical Engineering and in 1896 with a similar degree in Electrical Engineering.

After graduating he joined the laboratory force of the American Telephone & Telegraph Co. in Boston and worked there two years. In 1898 he was transferred to the engineering department of the Western Electric Co. in New York City, where he worked first on the preparation of telephone switchboard installation specifications and later on the development of apparatus and circuits. In 1905 he left the engineering department to become engineering assistant to H. B. Thayer, general manager of the company, and finally resigned from the company in 1906.

In 1906 Mr. Crane organized the Crane & Whitman Co. in Bayonne, N. J., for the development of gasoline automotive machinery and especially motor cars. This company later became the Crane Motor Car Co., and in 1914 was consolidated with the Simplex Automobile Co. He was president of the Crane Motor Car Co. and Vice-President of the Simplex Automobile Co.

In 1916 the Wright Martin Co. was organized and absorbed the Simplex company. Mr. Crane became vice-president in charge of engineering and remained in this position after the reorganization of the company as the Wright Aeronautical Corporation, about Jan. 1, 1920. He resigned from the latter company on March 15, 1920, since which time he has not been engaged in any regular business but has done some consulting work. Mr. Crane has taken a prominent part in the work of the Fuel Committee of the Society, and is Chairman of its Research Committee and Aeronautic Division.

Joseph VanBlerck

Second Vice-President VanBlerck, representing marine engineering, was born in Oudenbosch, Holland, Aug. 13, 1874. Early in 1902 he came to Detroit, where he continued his engineering work and began the construction of internal-combustion engines. In 1909 the VanBlerck Motor Co. was organized and later a factory was built at Monroe, Mich., for the production of the VanBlerck marine and commercial gasoline engines. Mr. VanBlerck acted as president and general manager of this company until early in 1919, when he formed his present connection with the Wellman-Seaver-Morgan Co., Akron, Ohio, organizing the motor division of that company for the building of truck and tractor engines. Mr. VanBlerck is also President of the J V B Engine Co., of Cleveland. He has been a member of the Society of Automotive Engineers for five years and during the past year served as Chairman of the Marine Division of the Standards Committee.

T. C. Menges

Second Vice-President Menges, representing stationary internal-combustion engineering, was born in 1872 at Prairie du Chien, Wis. After graduating from high school in 1890 he attended the University of Wisconsin until 1893, when he left to enter Cornell University as a student in mechanical engineering, being graduated therefrom in 1894.

His business career began with the Otto Gas Engine Works at Philadelphia in 1894, where he was assistant superintendent for two years, leaving to accept the superintendency of the Winona Mfg. Co., Winona, Minn. After building gasoline tractors at Winona he resigned in 1897 to engage in gold mining and for the next two years was manager of the Lyle Mining Co., Rainy Lake, Minn. Mr. Menges' connection with the internal-combustion engine industry has been continuous since 1898 when he became vice-president and general superintendent of the Davis Gasoline Engine Co., Waterloo, Iowa. In 1900 he was appointed general superintendent of the Waterloo Motor Works and held that position for eight years. For the next two years he was chief engineer of the William Galloway Co., also of Waterloo, and in 1909 he was appointed general superintendent of the Associated Manufacturers' Co., a position which he still holds. Mr. Menges was elected to Member grade in the Society on April 17, 1917. He is a member of the American Society of Mechanical Engineers and was vice-president of the National Gas Engine Association, the predecessor of the Gas Engine and Farm Power Association.

J. G. Vincent

Past-President Vincent was born at Charleston, Ark., Feb. 10, 1880. His education was received at a country school near Pana, Ill., and the Cote Brillinte Grammar School in St. Louis. At the age of 17 he left his father's farm and entered the service of Smith Vincent & Co., a firm of commission merchants of St. Louis. His natural

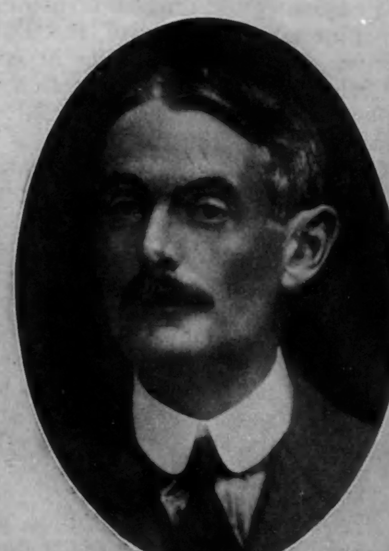
H. L. HORNING

B. B. BACHMAN

E. A. JOHNSTON

J. G. VINCENT

JOSEPH VAN BLERCK



H. M. CRANE

T. C. MENGES

inclination toward mechanics led him to a local machine shop where he worked as a machinist's helper by day, attending night school and pursuing a correspondence course in engineering at the same time. He became a machinist and afterward a toolmaker, joining the forces of the Universal Adding Machine Co., St. Louis, in that capacity in 1902. After a few months he was given charge of the toolmaking department. In 1903 he became connected with the Burroughs Adding Machine Co., which at that time was located in St. Louis. Shortly afterward this company's plant was moved to Detroit, and Mr. Vincent was promoted to the position of superintendent of inventions. He organized and had charge of a large inventions department, in which most of the improvements on the Burroughs adding machine were conceived or made practical.

In 1910 Mr. Vincent became chief engineer of the Hudson Motor Car Co. Since 1912 he has been associated with the Packard Motor Car Co. as chief engineer and vice-president in charge of engineering, except that for about two years he was engaged in Government work in connection with the development of the Liberty aircraft engine. Mr. Vincent's work on the design of passenger cars for the Packard company had led him to make an exhaustive study of the airplane type of engine in 1915-1916 and the early part of 1917. His service in the activities involved in the design and production of the Liberty engine is well known to the members of the Society and the automotive industry. In a paper presented by him at the 1918 Annual Meeting of the Society the theory and logic of the Liberty engine program were explained, and at the 1919 Annual Meeting he gave an historical account of the development and achievement of the engine.

Mr. Vincent held a commission in the Army as lieutenant-colonel, devoting his attention to the Air Service until the latter part of 1918. He was successively in charge of the engine design section of the Equipment Division and the airplane engineering department of that Division, which had the duty of passing on designs of aircraft engines as well as on airplanes, and of the airplane engineering division of the Bureau of Aircraft Production. After the armistice he accepted a commission as colonel in the aviation section of the Signal Officers' Reserve Corps. On Jan. 1, 1919, Mr. Vincent returned to Detroit to take up his duties with the Packard Motor Car Co., as vice-president in charge of engineering.

Francis W. Davis

Councilor Davis was born at Philadelphia on Aug. 19, 1887. His first business venture was at the age of 17 when he managed a motorcycle agency and had charge of a small machine shop which specialized in repairing automobiles and motorcycles and experimental work. From 1906 to 1910 he attended Harvard University and specialized in mechanical engineering with particular reference to steam and oil engines. He was graduated in 1910 with the degree of Bachelor of Science.

Upon leaving college he entered the service of the Pierce Arrow Motor Car Co., Buffalo, and took a course in the various departments of the factory. He was then placed in the experimental department and afterward transferred to the sales department as a sales engineer. In 1915 and 1916 Mr. Davis was consulting engineer on motor trucks for the British Admiralty and War Office. In this position he had to do with the selection of the equipment, its inspection, the training of the personnel, the establishment of repair and maintenance facilities and the operation of the equipment overseas. He returned to the Pierce Arrow Motor Car Co. in 1916 as assistant chief engineer of the truck department and since that time has been truck engineer and consulting engineer of the truck department, his present position.

Mr. Davis was elected a Member of the Society in 1916. He is a member of the Truck Division of the Standards Committee, the Truck Committee of the National Automobile Chamber of Commerce, the Federal Highway Council, the Permanent Committee of Washington Highway Transportation Conference, and chairman of the Society's Committee on the Science of Truck Operation.

Glenn L. Martin

Councilor Martin was born at Maxburg, Iowa, on Jan. 17, 1886. He is one of the pioneers of aviation in America. In 1909 he began experimenting with airplanes and like many of the early flyers taught himself to fly. The following year he was a constructor and as early as 1912 he began building up a strong organization. In 1916 the company bearing his name was the principal source of airplanes for the Army and at that time held the record of having built a comparatively large number of planes for the United States Government without a single serious accident to pilot or passenger. Mr. Martin was second vice-president, representing aviation engineering, during 1920. He is president and general manager of the Glenn L. Martin Co., Cleveland.

W. A. Brush

Councilor Brush was born at Detroit, Nov. 9, 1872. He was educated in the high school of his birthplace and also pursued some independent courses of instruction. Mr. Brush has been connected with the sales department of the Packard Motor Car Co., and was formerly head of the technical department of the Buick Motor Co., Flint, Mich. Together with A. P. Brush he organized the Brush Engineering Association at Detroit, to give technical advice to motor car builders. He has been business manager of that organization since 1913.

Mr. Brush was elected to membership in the Society January, 1914, and has taken a prominent part in the affairs of the Detroit Section, having served as its chairman. He has also rendered the Society valuable service as chairman of its Membership Committee.

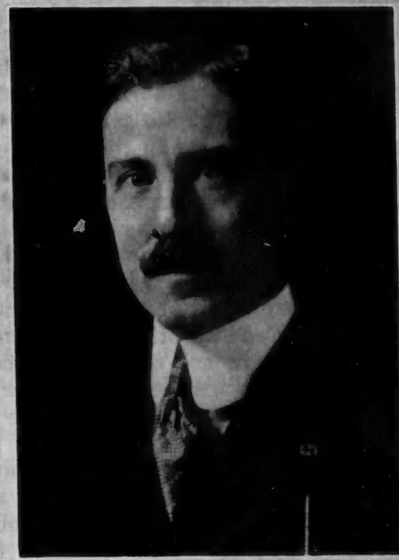
A. W. Scarratt

Councilor Scarratt was born in St. Paul on April 16, 1886. He received his early education in the public schools there. Later he was graduated from the Mechanic Arts High School of St. Paul after completing the engineering course. In 1905 he was employed by the Twin City Rapid Transit Co. as a draftsman in the mechanical engineering department where he was engaged in the design of car bodies and rolling stock of all kinds for approximately four and one-half years. He was then transferred to the power and electrical department, where his work consisted of powerhouse layouts and reconstruction work and sub-station design, and was later made assistant foreman at the shops of the Company. While with this Company he attended the University of Minnesota for three years.

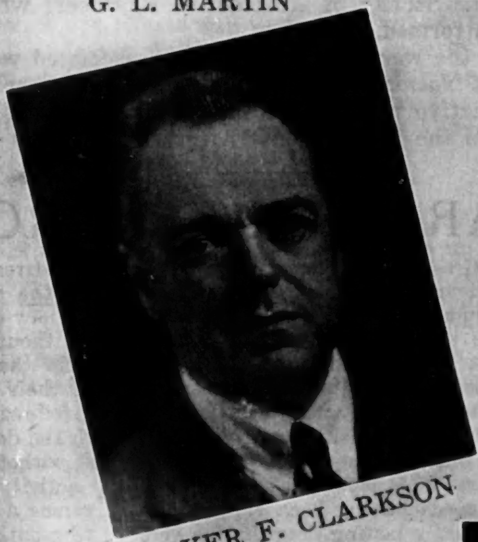
In 1913 Mr. Scarratt accepted a position in the tractor engineering department of the Minneapolis Steel & Machinery Co. He has been prominently identified with the development and production of the line of tractors built by this Company. He was elected to membership

G. L. MARTIN

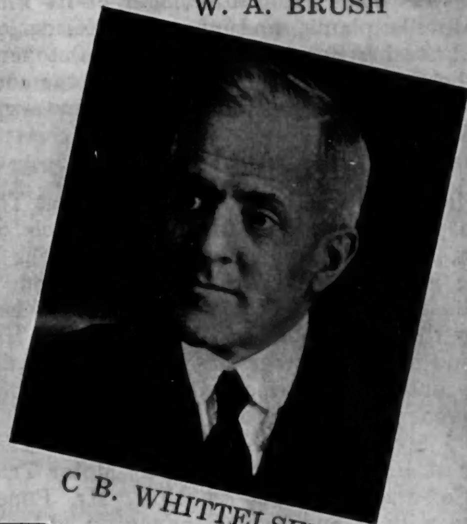
F. W. DAVIS



W. A. BRUSH



COKER F. CLARKSON



C B. WHITTELSEY

F. M. GERMANE

N. B. POPE

A. W. SCARRATT

in the Society in 1915 and is at present Chairman of the Minneapolis Section.

F. M. Germane

Councilor Germane was born Dec. 13, 1873, at Chicago, Ill. He attended the public schools of that city. After leaving school he engaged in the electro-plating business, entering in 1893 the service of the George L. Thompson Mfg. Co., Chicago, in charge of several factory departments including the polishing and plating departments. When the company was absorbed by the American Bicycle Co. in 1895 all the bicycle parts manufacturing plants of this organization were segregated and incorporated as the Federal Mfg. Co. From 1898 to 1904 Mr. Germane was in the sales department of the company, having charge of the Eastern territory. He was appointed Western sales manager of the Standard Roller Bearing Co. in 1904 and after serving in that capacity for approximately two years was appointed sales manager and transferred to the factory at Philadelphia. In March, 1917, when the Standard Roller Bearing Co. was purchased by the Marlin-Rockwell Corporation Mr. Germane was made general manager of its Philadelphia and Plainville plants, and upon the formation of the Standard Steel & Bearings Co., Inc., in October, 1919, to handle the manufacture of bearings for the corporation, he was made a vice-president of the new organization.

N. B. Pope

Councilor Pope was born July 17, 1879, at Thomaston, Me. He was educated at the public schools of Kennebunkport, Me., and Cambridge, Mass., and the Lawrence Scientific School of Harvard University from which he was graduated in 1902. Upon leaving college he was employed by the Pope-Robinson Automobile Co., Hyde Park, Mass., and for a number of years was engaged with different automobile firms with which he had varied drafting-room, shop and road experience.

In 1905 Mr. Pope joined the staff of *Horseless Age* and later of *Motor World*. When the Motor Trades Publishing Co. was organized in 1911, Mr. Pope became associated with it and is now managing editor of *Automobile Topics*.

Mr. Pope was elected to membership in the Society, February, 1908, and has presented a number of papers and discussions relating to fuel questions at meetings of the Society and its Metropolitan Section. He was secretary of the Metropolitan Section for two years and a member of the Miscellaneous Division of the Standards Committee for the same length of time.

Charles B. Whittelsey

Treasurer Whittelsey has been connected with the Hartford Rubber Works Co. since 1901, beginning as its purchasing agent. In 1905 he was made assistant to the general manager, in 1906 superintendent, in 1911 secretary and factory manager, in 1915 vice-president and factory manager, and in 1916 president and factory manager. He has served as president of the Hartford Chamber of Commerce and of the Hartford County Manufacturers' Association.

Mr. Whittelsey was elected to membership in the Society in 1910. In 1916 he was elected a Life Member. He was a member of the Standards Committee for several years, beginning in 1911, and served as chairman of the Tire and Rim Division in 1918 and 1919. Mr. Whittelsey was a member of the Council in 1912 and 1913, and was elected Treasurer in 1918 and reelected each year since.

Coker F. Clarkson

Secretary and General Manager Clarkson was born at Des Moines, Iowa, in 1870, and was graduated from Phillips Exeter Academy in 1888. In 1889 he was in Government service in the Post Office Department. He was graduated from Harvard College in 1894, pursuing post graduate work there for the next two years. He was next engaged in connection with the installation of an underground telephone system in Philadelphia for two years, after which time he came to New York City and spent several years in work on technical, legal, patent, laboratory and automobile subjects. From 1905 to 1910 he was connected with the Association of Licensed Automobile Manufacturers, as secretary of its Mechanical Branch, publicity manager and assistant general manager. During this time he was the editor of the A. L. A. M. Mechanical Branch Bulletins and of the A. L. A. M. weekly digest of current technical literature.

Mr. Clarkson has been secretary and general manager since 1910 of the Society of Automobile Engineers and then of the Society of Automotive Engineers when the latter was formed.

During the war Mr. Clarkson was associated with the Council of National Defense, and served as a member of the automotive products section of the War Industries Board, and the International Aircraft Standards Board.

WAR AND COMMERCE

During a great military struggle energies and resources are diverted from constructive enterprise, the supplying of consumption goods and the building up of new capital. During the period of the war the people go without many things that they would like to have, and some that they need, the money going into Government bonds or their energy being devoted to war activities. Immediately following the war there is the feverish effort to catch up with the demand; people want those things that they have done without during the war. This means intense commercial activity. The immediate needs having been supplied, there comes a period of pause, usually lasting from half a year to 18 months. At the end of this pause business does not go back to antebellum figures, but usually a new era develops slowly. There was a new era for England after the Napoleonic Wars, for Germany after the Franco-Prussian War, for the United States after the Civil War, and now, at least for the United States and probably for some of our associates in the conflict, after the war just past. We can confidently look forward to a great increase in our commercial prosperity.

The United States is at the crossroad today as truly as Tyre was at the crossroad of the caravan route of Asia and the trade of the Mediterranean. We are spread out across the paths of the westerly movement in the destiny of commerce. As to natural resources and the skill of our artisans, these need no comment. Despite high wages, Yankee ingenuity and American ability to organize mass production with improved labor-saving machinery have made it possible for us, for many years, to dominate the world's commerce in such articles as harvesting machinery, sewing machines, cash registers, typewriters, office supplies, automobiles and many other kinds of goods.

The only real insurance that will spread the risks of the depression between the crests of the waves of domestic demand is the allotting of a substantial quota of a firm's product for foreign commerce and the building up in the world's markets of a selling organization and clientele that will not necessarily fluctuate with the waves of demand at home.—Director R. S. MacElwee, Bureau of Foreign and Domestic Commerce.

Presidential Address of J. G. Vincent

IN opening my address at the close of a year's tenure of office I wish first to express as forcibly as possible my appreciation of the splendid support which has been received by the officers of the Society during the past year.

Those who attended the dinner a year ago will remember that I then urged the fullest cooperation of the membership of the Society at large, stating that I realized that we had a big job before us and needed all the help we could get.

On behalf of the officers who have served during the year just closed I want to take this opportunity to acknowledge the full measure in which support and cooperation have been given. I know that I voice the sentiment of the retiring officers when I state that it has been a real pleasure to carry on the Society's affairs, partly because we realized that we were accomplishing work of national importance but more particularly because we felt that the membership at large were in sympathy with our efforts and were cooperating to the limit.

I will endeavor first to give you a general picture of the Society's activities during the past year and then point out in a brief way some of its pending problems, as well as problems of a broader nature which the automotive industry faces at this time.

Increase of Membership

The work of the membership committee under the direction of its chairman, W. A. Brush, has been continuingly effective, the average number of applications received per month during the last seven months having been approximately 90 as compared with an average of approximately 77 per month during the same period of 1919. The total number on the rolls of the Society on Jan. 1, 1921, including Affiliate Member Representatives and Enrolled Students, was 5231, constituting a net gain of 465 since June 1, 1920, after 108 had ceased to be members, owing to resignation or nonpayment of dues. This is a net gain of 715 members for the year, as compared with 651 for the previous year, which I think you will all agree represents a healthy growth, all things considered.

Section Activities

Thirty meetings have been held in this season by the 10 Sections of the Society, the subjects discussed relating not only to engineering problems of the several automotive fields within the scope of the Society's activities but also to economic trends of today. These meetings have engendered a feeling of confidence through realization of the leadership of our industry among those businesses that are vitally necessary to the world's progress. The Sections established in Boston and continued at Washington after the war period have been successful from the start. The former makes possible the affiliation in sectional activity of a large number of members of the Society resident in New England who were formerly unable to take part in this important phase of the Society affairs. The Washington Section will, it is believed, be the channel of presentation of much valuable research data resulting from the conduct of tests by various branches of the Government.

The Sections as a whole are believed to be in a healthy condition. The total number of members of the Society who hold membership in one or more Sections has increased by about 300 during the past year.

The Sections Committee, H. R. Corse, chairman, has been faithful to its duties in the conduct of the Sections.

Administrative Committees

All of our Administrative Committees have carried their work forward actively and I desire to express my appreciation of their loyal support. Much as I would like to do so, time will not permit of my enumerating the large volume of work accomplished by the various committees, but I must mention the Finance and the Meetings Committees, which have carried an extra heavy burden during the year and accomplished results of untold benefit to the Society.

Standards Work

The work of the Standards Committee under the able leadership of Chairman Bachman, is proceeding in considerable volume on many important items. The Committee is making through 12 of its Divisions, 34 recommendations at this meeting, 13 on new subjects, 17 involving revision and extension, 3 cancellations of previously accepted recommendations and 1 a special report. In June and January of the last year, 14 Divisions reported 49 and 48 recommendations respectively. The number of Standards and Recommended Practices contained in the new edition of Vol. I of the S.A.E. HANDBOOK recently issued in rearranged form, is 210. The Committee has now in hand in various stages of progress more than 200 subjects. While a large amount of standardization has been accomplished, and many of the main features of materials and mounting dimensions of automotive apparatus have been codified, in one sense the real value of standardization is just beginning to be realized. There is no doubt that much more can be done by way of simplifying, facilitating and improving manufacture of the products with which we are specially concerned and the economical use of which in service must be fostered.

The Society is taking part in the procedure of the American Engineering Standards Committee, the first session of the Sectional Committee on Ball Bearings, organized by the American Society of Mechanical Engineers and the Society of Automotive Engineers, having been held recently and resulted in a decision to collect information as to volume and types of ball bearings made throughout the world, with a view to bringing about some international standardization. A Sectional Committee on Screw Threads has been organized in conjunction with the American Society of Mechanical Engineers, and another on Bolt, Nut and Rivet Proportions is in process of formation, as well as one on Safety Code for Aircraft, jointly with the Bureau of Standards. It is not intended that in the joint deliberation with other societies and organizations under the American Engineering Standards Committee plan, the Society shall give up any of its independence of work.

At a meeting held recently of members of the Lubricants Division and the Research Committee of the Society, a resolution was passed requesting that the United States Government Committee which, as a result of war conditions, formulates petroleum products specifications

for use in Government purchases, appoint an advisory board thereto constituted of delegates of representative associations. This action was in recognition of the fact that Government specifications, although promulgated for Government use only, have great weight in industrial practice, and the thought that industry should be consulted freely and fully in the establishment of specifications affecting it. The affirmative opinion is growing that it is feasible to establish lubricating oil specifications for general use. So far as gasoline specifications are concerned, the best view probably is that these should not be rigid but sufficiently flexible so far as periodical modification of them is concerned. The Society expects to be instrumental in demonstrating what the proper distillation curve or curves of gasoline are, with relation to ease of starting, satisfactory engine operation and economics broadly considered.

Aeronautic Handbook

The publication of the aeronautic handbook which the Society undertook something over a year ago has been delayed, owing in large part to the mounting cost of production, but it is expected that the altruistic and laudable purpose which stimulated this effort will be accomplished in some suitable manner in due course.

"Foreign Affairs" of the Society

We have been in an acute stage of overorganization for some time, nationally, industrially and professionally. In willingness and effectiveness of cooperation the Society is second to none, but there is a limit dictated by common sense to the scope of activities that can be beneficial jointly or severally. In addition to the strenuous internal activities of the Society, it has had to establish and conduct what is practically a department of foreign affairs. The Council of the Society has appointed no special committees this year except after careful consideration, to keep our methods reasonably free from complexity. There are, of course, several manufacturers' associations in our field of work with which we are naturally allied, as well as various Government Departments and Bureaus. In addition there are the following organizations with which we are cooperating or are from time to time asked to cooperate in greater or less degree:

- American Engineering Standards Committee
- American Petroleum Institute
- Society of Lubricating Engineers
- Engineering Societies Library
- Engineering Foundation
- National Research Council
- Federated American Engineering Societies
- Federal Highway Council
- Motor Vehicle Conference Committee
- Underwriters' Laboratories
- National Safety Council
- American Society for Testing Materials
- National Highway Educational Conference
- American Society of Agricultural Engineers
- British Engineering Standards Association
- National Advisory Committee for Aeronautics
- National Conference on Highway Traffic
- Mississippi Valley Waterways Association
- International Association of Industrial Accident Boards and Commissions
- Grinding Wheel Manufacturers of the United States and Canada
- United States Board of Surveys and Maps

The Federated American Engineering Societies

At the December meeting of the Council it was decided not to accept at this time the invitation extended to the Society to become a charter member of the Federated American Engineering Societies. The possibilities for achievement through a national organization dealing with the non-technical activities of engineers are appreciated, and it is of course felt that the Society must accept responsibilities in keeping with position in the engineering world. Engineers are justly proud of their reputation for efficient organization. Under the industrial conditions which now exist in the United States, it is more than ever advisable that questions of economy both in money and in time be given the most serious consideration. Every new organization created must be financed and much time must be spent in the study of its proceedings, provided its work is to be made effective and really worth while. There is a tendency among some leading engineering societies toward welfare and political work in connection with the general status of the engineer as such. Much of this movement is undoubtedly justified or at any rate inevitable. We have a very large amount of work to do right in the Society which must be done. We must assist in carrying the general burden but arrange that our own immediate work shall be sacrificed as little as possible. To do the work we have in hand properly, a large amount of thorough study and attention is necessary and we have not the staff nor the income to permit much work not having a direct bearing on the promotion of the arts and sciences and standards and engineering practices connected with the design and construction of automotive apparatus and internal-combustion prime movers. Our present standing and prestige has resulted from close attention to our own matters and I believe that a properly conservative policy indicates the assumption that this will continue to be the case in practically the same degree as heretofore.

The Council and Office Staff

I wish to repeat what I said on a former occasion, that I believe that no commercial board of directors in our field is more conscientious and effective, relatively speaking, than the Council of this Society is. Before the close of my administrative year, I wish to say from actual and intimate knowledge that I am of the opinion that no office staff of a company with which are members are connected is more hardworking or competent than that of the Society. It is a striking, although perhaps natural, fact that few members of the Society really understand the nature, extent and intricacies of its work. I can testify that close contact with its affairs enhances greatly appreciation of these. The physical arrangement and departmentization of its offices were described in a recent issue of THE JOURNAL. There is not now time and this is not the occasion to itemize the activities.

When Mr. Clarkson became Secretary and General Manager of the Society 10 years ago, its office equipment was desk space in a downtown office, there were less than 400 members and he was the sole employe. Today the staff of the Society is constituted of 50 persons, we have 7500 sq. ft. of office floor space, and there are over 5000 members resident throughout the world. I shall not enlarge at all at this time on the well-known achievements of the Society, but refer to the groundwork on which they are based.

From a shoe-string treasury in 1910, the worth of the Society in quick assets including cash on hand, accounts receivable, securities and inventories, has become fully $200,000. The general reserve, constituted of unexpended income accumulated during ten years, is $130,000, or $13,000 average per year for 10 years. One indication of

the volume of business of the Society is that current incoming and outgoing first-class mail ranges from 500 to 1000 pieces per day. The Society's job is to give service to 5000 members as well as various individual and corporate non-members. It has been stated repeatedly that the standing of the Society is determined by the merit of its printed matter. The editorial work involved in the publication of papers, reports and data sheets is one of the chief burdens of the Society staff. A survey must be made of publications issued throughout the world containing automotive engineering matter of value. The conduct of the affairs of the Council alone constitutes a considerable mass of business. The meetings of the Society, particularly those termed Annual and Semi-Annual, are large undertakings. The financial affairs of the Society require considerable attention. The publication of the TRANSACTIONS, THE JOURNAL and S. A. E. HANDBOOK involves at least three separate and distinct readings of each article or document. All of these matters as well as Sections and Standards questions and considerations of policy are originated or centered at or conducted by the Society staff.

There were published in THE JOURNAL[1] diagrams showing the proportional sources of income per dollar received and proportional use per dollar expended by the Society during the last fiscal year, as well as the same information with respect to the total expense per member per year. These figures show in a clear manner the remarkable service the Society is giving the members in the form of valuable production not securable elsewhere, the cost of this being more than four times the amount of the average annual dues received by the Society from members.

PROBLEMS OF THE SOCIETY

The Society is perhaps best known for its standardization work. It has undoubtedly been most effective as well as a world-wide leader in this respect. The further work will need close attention, both as to the best system of internal procedure and in relation to national and international standardization as such. For some time the Society has been disseminating widely information with regard to its standards at a considerable financial loss and a very liberal policy in this respect should be maintained. There is probably room for improvement in the fundamental organization of the committee personnel and it is of economic importance that accurate information of a comprehensive character should be collected and collated as to the actual extent of the use of the standards, and as to the need for revision or cancellation of any of them. Likewise some suitable system should be inaugurated of listing sources of supply of products fabricated in conformity with the S. A. E. Standards and Recommended Practices. Moreover, it is not unlikely that more detailed information in connection with what standardization is contemplated should be published prior to preliminary definite action, bearing in mind that great care should be exercised in distributing advance advices to avoid misunderstanding as to their tentative nature.

The matter of the foreign relations mentioned above, that is, cooperative procedure with other organizations of this country not directly concerned with our work, will need further careful attention and handling. In addition, it should not be forgotten that international cooperation in automotive engineering standardization is probably not far off.

Some vexing questions have arisen with regard to the effect on the standardization work of claims to rights under letters patent and in connection with commercial considerations governed by competitive conditions without regard to patent rights. An instance of the latter class is the standardization of tires. At a joint meeting of the Tire and Rim and the Truck Divisions held at Cleveland in November, various other automotive vehicle designers and members and guests being present, resolutions were passed looking toward the coordinating of the effort of various organizations interested in tire and rim standardization, and the making of any necessary economic studies; and in this connection the Council has appointed a committee to report on the whole general question, with reference particularly to pneumatic tires for passenger cars and motor trucks, including limits for oversize tires, rim sections for pneumatic tires, metric tire sizes, and maximum wheel load for highways, it being understood that the various commercial considerations involved should be given particular attention. I have accepted the chairmanship of this committee and it is proposed that the National Automobile Chamber of Commerce and the Rubber Association of America shall be represented thereon.

It has been decided, after discussion of the possible activities of the Society in research work, to maintain a Research Committee. It is not considered feasible that the Society should engage in research work directly by the establishment of a laboratory or the organization of a research force. It is believed, however, that it should be ready to take up and direct from time to time certain lines of research, the duties of the committee consisting in passing on suggestions submitted to it and in deciding upon the best way of carrying out any work believed to be desirable, including the securing of financial assistance from the industry to this end.

The work on internal-combustion engine fuel that the Society has been doing will, of course, have a strong bearing on the Research Committee work. At a session held here recently attended by representatives of the American Petroleum Institute, the Bureau of Mines, the Bureau of Standards and the Society, specific recommendations for fuel tests were formulated for submission together with estimate of expense to the National Automobile Chamber of Commerce and the American Petroleum Institute with a view to starting some actual joint tests as soon as possible.

I want to stress as much as I can the importance and value of our committee work. The Society is absolutely dependent in many of its activities upon the generous assistance of experts qualified in their respective special lines of endeavor, and their proceeding together in deliberation upon the various phases and grades of problems before us spells the best form of progress in our field.

With relation to the other class of work conducted by the Society, I want to urge upon the members the need of our having for presentation at Society and Section Meetings and for publication in THE JOURNAL, professional papers of the highest possible order of merit and value. You are urged to assist the Meetings Committee as to this.

The proper balance of the so-called automotives should never be neglected in the proceedings of the Society. At this Annual Meeting there are to be presented papers and discussions having special reference to passenger cars and aircraft, as well as to the automotives in general. During the last month a Motor Boat Meeting of the Society was held, and Motor Truck and Farm Tractor

[1]See THE JOURNAL, January, 1921, p. 11.

Meetings will be held next month in Chicago and Columbus respectively.

The financial condition of the Society should be wisely conserved. While its funds, including surplus monies, are adequate for our present activities, they do not permit of any large scale operations in the way of research, for example. So far as current income with relation to expense is concerned, the Society is probably in as good a condition as any of the societies. Current income rather than surplus monies should, of course, determine budgeted current expense.

Industrial Problems

The automotive industry today finds itself facing problems of the utmost seriousness and importance. Naturally, no troubles that can arise at this time are so grave as those of the early years of the industry, when in fact the very life of the industry itself was often at stake. But in the present situation not only the growth and prosperity of the industry but to a greater extent the prosperity and development of the whole country depend upon the solution of many problems which are peculiarly within the scope of the Society.

Primarily the acuteness of immediate conditions is not due to these great problems. The industry has suffered seriously and is threatened with further suffering as a result, partly of general conditions which have affected all business, and partly of a serious misunderstanding in regard to the automotive industry which has arisen in the public mind. This misunderstanding has resulted to a considerable extent in causing the automotive industry inconvenience and distress entirely out of proportion to that suffered by other industries and entirely out of proportion to its just deserts.

There still remains in the public mind a vague belief that the passenger automobile can truthfully be called a "pleasure car"; in other words, that it is to a large extent a luxury. There even remains in the minds of many the feeling that the automotive truck is an expensive form of transportation and should be discouraged. In addition, it should be added that the rapid growth of the industry has caused a certain amount of jealousy among other men and also that the demands of the industry have furnished a convenient alibi to purveyors of steel, rubber, woolen, cotton and other materials entering into the production of automobiles when they have failed to make promised deliveries to other industries.

It is largely as a result of these misunderstandings that the automotive industry finds itself in its present condition. These beliefs, erroneous as they are, have had a decided effect upon the sentiments both of bankers and of the buying public. These sentiments are responsible for the effort now being urged before Congress to impose greatly increased taxes upon both cars and trucks.

It seems impossible that any policy so suicidal to the prosperity of the whole country, as well as one so unjust to a great industry, can be adopted. It is surprising that any argument is necessary in regard to the truck. The Government itself has records showing that the postal express lines running over distances up to 248 miles from Maryland into Washington resulted in selling farm products to consumers at something like 43 per cent less than the normal market prices. Other statistics show that truck haulage can often produce a saving over rail transportation up to distances around 200 miles. The advantages of truck transportation for shorter distances, especially in cities, have been proved by hundreds of thousands of truck owners. Even a slight investigation would show these services conclusively.

The fact that the passenger car is a factor of equal economic importance is not so easily demonstrated by statistics and this perhaps accounts for the feeling that the passenger car is a luxury, although the car passed out of that condition at least six years ago. A recent questionnaire sent out by the National Automobile Chamber of Commerce showed that 90 per cent of all passenger cars are used more or less for business purposes and that more than two-thirds of the total mileage run by passenger cars is for business. So the utmost that can be charged against the passenger car today is that it gives pleasure after it has done a full day's work. The questionnaire brought out an even more startling fact, that the average motor-car owner increases his earning capacity about 57 per cent through its use. The value to the farmer has been shown time and again and altogether no doubt can remain in the mind of any candid man who investigates that the automobile is far more than paying its own way today. In addition, of course, are the great intangible values that the automobile is giving, its contribution to comfort, pleasure and health.

Yet these prejudices have already seriously affected the automotive industry and it has been shown that they threaten its future even more seriously. Although not a problem in engineering, this condition is a matter to which members of the Society should give most careful attention and in every way possible the Society should bring home to America the very high value of the automotive industry.

While the matters affecting public opinion and Governmental action are under discussion, mention should be made of the increasing need for a Federal licensing system. The greatly increasing use of the motor truck in interstate commerce and occasionally over very long distances has made this a serious, if not vital, problem. The general practice of States of applying upon road building the fees received for automobile licenses presents some complications in the search for methods of handling the Federal licensing system, but the inconveniences caused by the present arrangements are so serious that the matter should be taken up promptly and with vigor. There is no doubt that a solution can be found that will be fair to all concerned.

The handicaps upon the industry which are peculiarly within the province of the Society and which must be solved before the automobile can render its full service to this country fall under three general heads: road construction, fuel and cost.

Roads

In the matter of roads, progress during the past year has not, in my opinion, been in proportion to the large amount of money expended on construction. Many of the roads built within the last few years of what was fondly called "permanent construction" are rapidly breaking up and too often are being replaced with roads of equal impermanence. In the meantime such roads as we have are so congested as to cause serious delays, expense and even danger to the users of both cars and trucks. While neither of these important problems comes within the direct province of the Society, they are so closely allied to our work as to make it imperative that we cooperate to the fullest extent with those organizations having the work in charge.

Studies that have been made during the past year have contributed greatly to our knowledge of the effect of vehicles on the roads. We have learned how much road surfaces can be saved by increasing the proportion of

sprung weights to those of unsprung weights in a truck. We have learned considerable regarding the amount of load that should be carried per square inch of bearing surface of tires upon the road. Care should be taken to make certain that these lessons are applied to the fullest extent in the building of vehicles and in their loading so as to lighten the task of the road engineers who are attempting to solve the problem of constructing surfaces that will withstand modern traffic.

In the matter of congestion, the assistance we can give is largely educational. It is becoming evident that the automobile is following the lines of the development of the railroad in many ways and one of these is in the sharp division into the two classes of passenger and freight traffic. The railroads, to handle their work economically, have been forced to build first two and then four tracks. It seems obvious that the automotive traffic also will eventually demand two and then four-track roads. The Society should cooperate vigorously in teaching the public the need of such roads and in working for their construction. Until they shall have been completed, we shall never be able as a nation to get from the automotive car or truck more than a small part of the service they are prepared to render us.

Fuel

The second great engineering problem which confronts the industry has to do with fuel. We have now for some years seen an increasing cost of fuel, together with decreasing quality, indicating that there is a real shortage and that the demand for gasoline has outstripped the supply, long before that demand has reached the volume that it will reach when the internal-combustion engine shall have been adapted fully to America's needs. Unless the cost of fuel can be considerably decreased and its quantity considerably enlarged, we are not far from the time when the industry will have to cease its growth with a good half of its work still undone.

The solution of this problem will need the cooperation of three parties. The oil industry itself must expand as rapidly as possible, replace antiquated refining methods with modern, and practice conservation to the limit. The public must be educated to get the maximum amount of mileage out of every gallon of gasoline. But chiefly we automotive engineers must revise and improve our designs to get every ounce of power possible out of every drop of gasoline.

Considerable steps have been made toward a solution during the past year. Most important perhaps is the understanding that has been reached between automotive engineers and the American Petroleum Institute. This should result in an intensive cooperation between the automotive industry, represented by this Society, and the oil industry, represented by the American Petroleum Institute, to the great advantage of both, as well as to the users of automotive equipment.

In the meanwhile a great volume of research and experimental work has been done and some important results have been achieved in adapting engines to use present-day fuels efficiently. This has been largely a matter of inlet-manifold design, including suitable heating means for obtaining improved vaporization and distribution of the mixture of fuel and air in the different cylinders. Considerable attention has been paid also to carburetion and thus, as a result, a somewhat improved gasoline economy has been attained. The fact remains, however, that a majority of the engines in use today are poorly equipped to handle the present grades of fuel, since they were designed several years ago. This in itself is responsible for a considerable waste of gasoline, accompanied by rapid deterioration of the engines. This condition can generally be alleviated by the use of suitable attachments for heating the manifold, and the public should be encouraged to use such devices. In general, there should be a broad campaign to teach the automobile driver how to get the utmost efficiency from his engine. I believe that this could be carried to a point where it would result in a saving of nearly 10 per cent of the gasoline now consumed.

There are a number of reasons to expect relief in the distant future from fuels other than gasoline, but the development is likely to represent a slow and tedious process. In the meanwhile we are faced with an actual situation and I can see no way of legislating increased gasoline mileage into cars or of passing laws which will compel intelligent operation by drivers. It will be necessary, therefore, to outline some definite plan of immediate procedure and, in my opinion, the most important things to be accomplished are as follows:

(1) Work out plans for the general education of operators of automotive apparatus along lines of fuel conservation using as publicity mediums:
  - *a* The service stations of the builders of automotive apparatus
  - *b* Gasoline supply stations
  - *c* Local automobile clubs
  - *d* Automotive trade journals
  - *e* Any other available means

(2) Educate the automotive engineers as to the problems confronting the oil industry and keep them posted as to the probable grades of fuel that will be available, at least two years in advance of making any change in fuel specifications

(3) Educate the engineers of the oil industry as to the problems of the automotive engineer in order that they may be fully conversant with the whole subject and be in a position to adapt the fuels to the needs of the internal-combustion engine insofar as possible

(4) Bring about thorough cooperation between the automotive industry and the oil industry and thus avoid misunderstandings and working at cross purposes which, I believe, have been common occurrences in the past

In justice to the industry, I believe it would be well to set down what the automotive manufacturers are contributing toward internal-combustion engine fuel conservation.

(1) Lighter and more efficient cars and trucks

(2) Improved efficiency of carbureters

(3) Greatly improved intake manifolding and heating devices of various sorts, all of which have for their object improved vaporization and more even distribution of the fuel to the various cylinders

(4) Improved temperature control of engines to overcome the inefficiency of cold engines

(5) Improved fuel feed systems

(6) Elimination of excessive friction in the mechanism, with consequent reduction of mechanical losses

(7) Improvements in the resiliency of tires, which alone has effected a gasoline saving of as much as 10 per cent

(8) More efficient lubricating systems and better piston fits to prevent fuel passing into the crankcase with consequent loss of gasoline and the attendant contamination of the lubricating oil

(9) Exhaustive investigations into the possibilities of increased compression, which will eventually result in an increase of at least 10 per cent in gaso-

line mileage and probably considerably more. In connection with this research work, automotive engineers had to delve into the mysteries of the molecular structures of the fuel because it is the make-up of present-day fuel alone which limits the compression, as was clearly brought out in Mr. Kettering's talk before the American Petroleum Institute

(10) Technical service divisions have been organized by the majority of automotive manufacturers to keep closely in touch with the operators of their devices and help maintain the engines and vehicles in the best possible operating condition at all times, reporting back to the factory all troubles and assisting in their cure by suggestions for improvements

Manufacturing and Operating Cost

The third engineering problem which faces the industry is that of cost in both manufacture and operation. It is obvious that we are facing a considerable period of readjustment, economy and retrenchment, and it behooves the industry to meet these conditions frankly and fully. The automotive industry has made considerable strides in the past year toward obtaining both smaller cost and smaller operating expense by the introduction of lighter cars adapted to supplement the larger heavier cars, which, however, will always be in demand by those who can afford the maximum in luxurious transportation. The fact remains that we have not begun to approach the high gasoline mileages obtained with typical light European cars. The reason for this lies in the demand of the public for cars that will go practically anywhere on high gear and have a very high rate of acceleration. Until the driving public is ready to make some concession in this direction, the automobile builder will not find it profitable to turn out cars capable of much higher mileage. The good roads movement also has an important bearing on this question. With the construction of more routes which can be comfortably negotiated with smaller cars, in contrast to the previous roads where a heavy car was essential for comfort, the use of light cars will naturally increase. So there is a direct relation between the good roads movement and automobile economy.

I have purposely confined my discussion of these problems to a consideration of their bearing on the car and truck branches of the automotive industry, because I do not feel qualified to discuss in detail their possible affect on the tractor, marine engine, and farm power divisions. It is safe to state, however, that these newer branches of the automotive industry are vitally interested in the fuel problem and improved general efficiency as well as reduced cost. Although I realize that this discussion has become rather lengthy, I do not feel justified in bringing it to a close without touching briefly on the aircraft situation, as I think that this is particularly a matter of national importance and one which, therefore, should have our most loyal support.

Aircraft

Aircraft development during the past year has followed along rational lines on a scale commensurate with the service which present-day aircraft are able to furnish. The airplane has not leaped into the commercial popularity which some of its ardent and perhaps over-optimistic supporters believe is warranted, nor on the other hand has the industry gone entirely to the "bow wows," as some of our calamity howlers would lead us to believe. The airplane is being developed by arduous labor and concentrated effort which must ultimately result in aircraft playing an important role in passenger, mail and express transportation. We must bear in mind that the extraordinarily rapid development of the airplane during the war was due primarily to the service which it alone could render. In peace time, however, aircraft transportation is in direct competition with the older transportation methods. At present, its field is confined to those special cases where the tremendous speed or the ability to fly direct between two points, perhaps inaccessible by other means of locomotion, or at best by tortuous routes, or perhaps necessitating the change from railroad to steamship and back to railroad, are the influences resulting in the choice of aircraft transportation.

The last year has seen the development and extension of typical services for which airplanes are well fitted in their present stage of development. The steady expansion of the air mail service should be a source of intense national pride, this being by far the most ambitious undertaking of its kind in the world. During the past year the air mail service has been extended from coast to coast with numerous connecting lines in operation or planned for the immediate future. We should see that appropriations are ungrudgingly made for the further development of the air mail, for not only is business already reaping the benefit accruing from the faster means of communication, but this service, as I have frequently pointed out, forms an invaluable source of personnel and materiel available in a national emergency. Furthermore, I know of no better stimulus for the growth of commercial aviation than the splendid records now being made for reliability and reasonably low cost of operation by our postal air service.

For sheer audacity and courageous execution, I can think of no better example than the famous Alaskan flight undertaken so successfully by the Army. This afforded a wonderful demonstration of present-day reliability of engines and planes, as well as reflected superb efficiency and endurance on the part of the personnel. It must be borne in mind that any forced landing anywhere over hundreds of miles of the difficult territory covered in this flight would have been disastrous if not fatal. There were not any radical improvements in these planes or engines, but the details of construction and installation had been carefully worked out and the crew were specially picked for their knowledge and experience.

The Key West-Havana Service has had an auspicious start and will doubtless attain the same popularity as has been accorded the British and French Cross-Channel Service.

The Navy has prosecuted important development work with the limited funds available and at the present time the Naval Air Service is conducting joint maneuvers with the fleet on a larger scale than heretofore attempted. The Army Air Service has likewise been extremely active in research work and has accomplished many detail improvements, as well as arrived at satisfactory types of planes for the various kinds of war service.

Summing up, it is evident that the past year has seen a steady improvement in the reliability of the airplane, an extension in the use of aircraft where this was justified by the inherent advantages of this system of transportation, and attainment in the field of research limited alone by the funds available. We can look forward to greater accomplishments in the coming year, provided adequate appropriations are secured. Design tendencies in general will include a greater attention to details of

(*Concluded on page* 162)

Fuel Problem in Relation to Engineering Viewpoint

By A. L. Nelson[1]

Annual Meeting Paper *Illustrated with* Photographs and Drawings

It is believed that never before in the history of the Society of Automotive Engineers has a single problem been so universally studied as the fuel problem which is confronting us today. It also is believed that never before have we had a problem which includes such a wide scope of work. The solution calls for the service of every class of engineer, inventor and scientist. It is most gratifying to realize the large amount of ingenious research that is giving us day by day a broader view of the problem. When we have worked out the proper viewpoint and thoroughly understand our problem, the eventual solution should follow with relative ease. It is on this ground that particular emphasis is laid on the engineering viewpoint for, obviously, this will have a large bearing on keeping our efforts going in the right direction.

This paper does not attempt to give highly scientific information, the correlation of the last word in test data or to claim the solution of even the merest detail of the fuel problem; its real object is to appeal for a broader viewpoint and give a few illustrations and tests which show that the solution of a problem may lie in an entirely different method than that which often becomes stereotyped by sheer usage, rather than by its specific merit. The American engineer is too ingenious, too susceptible to practical new viewpoints to follow an old beaten path in only one direction, unless it follows from being off-guard and letting it become a habit. In the solution of the fuel problem we undoubtedly will have to change some of our old habits, replacing them by studiously worked out viewpoints. The illustrations given will clarify what is meant and will, together with the tests, serve to give a quantitative analysis of the merits of the results obtained by the changes in viewpoint. The further object of this paper is to seek the correlation of the experience of the entire engineering fraternity, to obtain their comments and seek their suggestions. It is hoped that the discussion following the reading of this paper will bring out much valuable information and materially expand our viewpoint of the fuel problem.

Recognition of Cooperation and Assistance

The eventual solution of the fuel problem will likely be the correlation of the proper solution of the almost innumerable details. We cannot, therefore, help but applaud the successful efforts of men whose work has earned our highest esteem, nor can we help but applaud those that are succeeding to a lesser degree. That this paper might be of interest to as large a number as possible a preliminary paper was submitted to representative engineers asking for suggestions, criticism and any comments which would help make the final paper a cooperative one. The generous response was very helpful indeed. The sincerest thanks and the assurance that the help is highly appreciated are extended. Many of the suggestions offered are indeed worthy of separate papers and, therefore, it is impossible to incorporate them in this. As a case in point, the importance of turbulence will not be mentioned, but it is hoped that the discussion following the reading of this paper will cover the matter as fully as possible.

As a matter of an expression of gratitude to those whose help has been most liberal the following names are mentioned. I am particularly indebted to C. S. Crawford, Harold Nutt, J. G. Vincent, H. L. Horning, H. M. Crane, C. F. Kettering, C. F. Johnson, E. A. De Waters, C. R. Richards, C. P. Grimes, Thomas Midgley, Jr., Frank Johnson and others; also to the members of the engineering department of the Premier Motor Corporation for their assistance in the preparation of the paper.

Some remarks will be made later which it is hoped will not be misconstrued. They refer to faults in regard to which the most exacting engineers cannot be justly accused and will not apply to them. However, if we are to be frank with ourselves, the remarks will apply to all of us to at least a small degree without being looked upon as non-constructive criticism. However well the specialist may know his particular subject, if he is presented with an entirely different viewpoint of some specific problem, the aspect of the problem may be entirely changed. This may lead to an easier solution than that obtained without the change in viewpoint. We are all familiar with the cleverness with which the scientists have worked into the very heart of natural sciences.

For instance, in mathematics, there are clever tricks making possible the easy solution of certain types of differential equation. These are nothing more or less than simple inventions that would have hindered the progress of mathematics had they not been discovered. It is thought that discoveries of analogous schemes will have a large bearing on the eventual solution of the fuel problem. When we compare the present stage of our problem with the highly developed stage of the natural sciences, it is thought that all of us will willingly open our minds fully to the possibilities of changes in viewpoint.

Let us consider how we often discuss some of our problems affecting the fuel situation, without the important specific correlation of engine and chassis data. We know off-hand the general engine characteristics at full, three-quarter, one-half, and one-quarter load. We know the power, friction losses, economy and the like. This is all very proper and applies very well to what the engine *can do*, but how about the more important questions of engine characteristics while working at loads that it is *called upon to do* in the car? How much specific information can we give off-hand on these more important engine characteristics so vital to the solution of the fuel problem?

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TABLE 1—CAR CHARACTERISTICS FOR CONSTANT SPEED

Car Speed, m.p.h.	Power Required of Engine, b. hp.	Rear-Axle Gear-Ratio 4.5 to 1: Engine Speed, r.p.m.	4.5 to 1: Engine Pull at 15.756-In. Arm, lb-in.	3.5 to 1: Engine Speed, r.p.m.	3.5 to 1: Engine Pull at 15.756-In. Arm, lb-in.	2.5 to 1: Engine Speed, r.p.m.	2.5 to 1: Engine Pull at 15.756-In. Arm, lb-in.	Constant To Be Multiplied by the Ounces of Gasoline Consumed in 2 Min. To Get the Fuel Consumption in Pounds per Brake Horsepower per Hour	Constant To Be Divided by the Ounces of Gasoline Consumed in 2 Min. To Get the Miles per Gallon[a]
10	2.40	450	21.3	350	27.4	250	38.4	0.7820	32.27
15	3.75	675	22.2	525	28.6	375	40.0	0.5000	48.40
20	5.20	900	23.1	700	29.7	500	41.6	0.3610	64.53
25	7.00	1,125	24.9	875	32.0	625	44.8	0.2680	80.67
30	9.10	1,350	27.0	1,050	34.7	750	48.5	0.2060	96.80
35	11.50	1,575	29.2	1,225	37.6	875	52.6	0.1630	112.90
40	15.10	1,800	33.6	1,400	43.1	1,000	60.4	0.1240	129.10
45	20.10	2,025	39.7	1,575	51.0	1,125	71.5	0.0933	145.20
50	27.60	2,250	49.1	1,750	63.1	1,250	88.4	0.0680	161.30
55	36.50	2,475	59.0	1,925	75.9	1,375	106.2	0.0514	177.50
60	46.20	2,700	68.5	2,100	88.0	1,500	123.2	0.0406	193.60

[a]The weight of 1 gal. of gasoline is taken as 96.8 oz.

DATA RELATING TO TABLE

Outdoor Temperature (average) deg. fahr.	76
Barometer (average) in. of mercury	30.15
Weight of Car with Fuel and Two Spare Tires, lb.	4,340
Weight of Driver, lb.	180
Total Weight of Car and Driver, lb.	4,520
Tires	Firestone Cord
Size of Tires, in.	33 x 5
Air Pressure, Rear Tires, lb. per sq. in.	50
Air Pressure, Front Tires, lb. per sq. in.	45
Course	Indianapolis Speedway
Pavement	Brick
Length of Course, miles	½
Direction of Driving	North and South
Roll of Right Rear Wheels per Turn, in.	106.25
Roll of Left Rear Wheels per Turn, in.	105.00
Average Roll of Rear Wheels per Turn, in.	105.62
Number of Turns per Mile	600
Exhaust Cutout	Open
Oil	Mobiloil B

We know the general bearing in a vague way that the chassis weight, rear-axle gear-ratios, engine size, piston compression ratios and similar factors have on the fuel economy. The more complicated cases of rapidly changing driving conditions are little understood in a specific way. Are we not even weak on the conditions obtaining at constant-speed driving, apparently for no other reason than our *habit* of neglecting to investigate this important matter? This investigation can be made readily after determining the power required to drive the car at constant speeds.

Engine Power Required to Drive the Car at Constant Speed

In relation to car speed, Fig. 1 shows the engine brake horsepower required to drive one of our American cars of the large-car class. The figure also shows the brake horsepower available and the percentage of the available power used at each speed. Table 1 gives the data relative to car weight, tires and course. It also gives the brake horsepower required for car speeds from 10 to 60 m.p.h., together with the engine speed and torque for rear-axle gear-ratios of 4.5 to 1, 3.5 to 1 and 2.5 to 1. The constants given in the last two columns are used when running engine tests on the dynamometer to compute the gasoline consumption in terms of pounds per brake horsepower per hour and miles per gallon.

The method of obtaining these data is to drive the car on a given course at constant car speeds corresponding with a fixed carbureter throttle setting, then to remove the engine from the car to the dynamometer stand to determine the power at those settings and the engine speed corresponding to the car speeds. It is necessary to duplicate very accurately the fixed throttle settings when the engine is put on the dynamometer; therefore, a micrometer adjusting screw was attached to the carbureter throttle-shaft mechanism, always using full turns only and then measuring from the locking nut to a fixed line on the screw as a means of recording the setting. The speed of the car was obtained by timing with a stop-watch on a ½-mile measured course, driving in both directions for each setting to eliminate the wind resistance by taking the average speed. The engine speed is obtained by noting the roll of the rear tires per turn and with the car speed and rear-axle gear-ratio, the number of revolutions per minute is calculated.

The average result of the dynamometer tests is

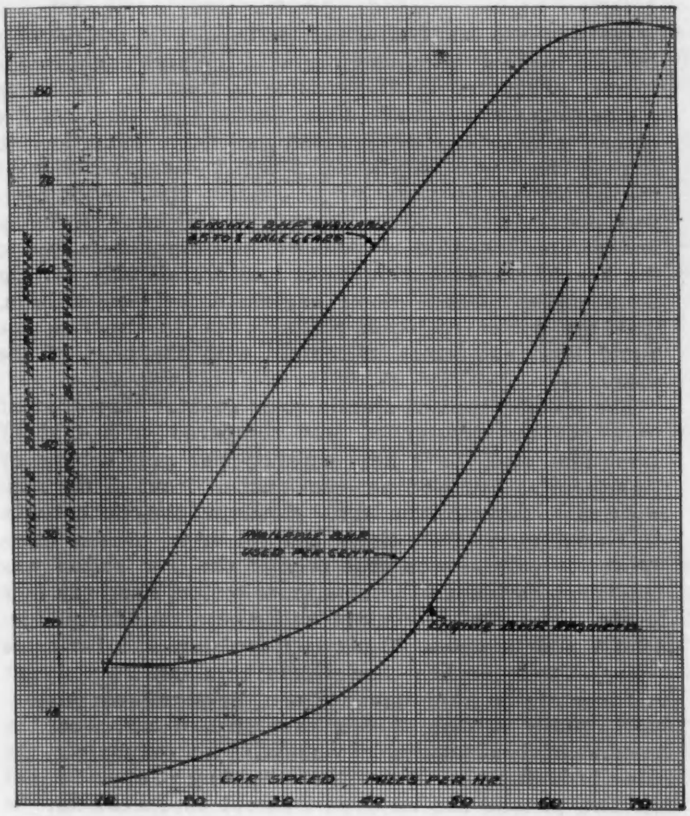


Fig. 1—Engine Power Required at Constant Car Speed

plotted and the results of the smooth curve drawn through these points are given in Table 1. Several important details, such as cooling water temperatures, oil temperatures, air pressure under the engine hood, and the like, need not be given here. However, it is suggested for accurate work that, in addition to the use of fixed throttle settings, manometer readings be taken of the intake-manifold depression together with the air temperature. The method of keeping the water circulation the same on the dynamometer as in the car will be given in describing the equipment used in the engine tests to follow. Referring again to Fig. 1, note that the usual engine characteristics of even one-quarter load do not apply below 40 m.p.h. At average driving speed the engine is only working at 16 to 19 per cent of full load.

By means of the data given in Table 1, which states the standardized power requirements of this particular model of car, we can analyze readily the engine characteristics by running tests on the dynamometer. It is obvious to expect that poor economy is caused by misapplication of the engine rather than poor engine economy. The analysis should give us relative values on which to consider the feasibility of using two-speed rear-axles, more speeds in the transmission, or perhaps an entirely new and better way will be devised eventually to keep the load factor of the engine high to obtain better economy. Tests will be given further on giving quantitative analysis of the conditions existing.

The conditions revealed by the correlation of engine and car characteristics are so bad that both the public and engineers need a decided change in viewpoint; the public in what they demand, and the engineer in what to furnish and in what to educate the public to expect. Some illustrations will be given next to demonstrate results following from a change in engineering viewpoint.

Higher Piston Compression Ratios

As an illustration of remodeling our viewpoint, let us consider the effect of using higher piston compression ratios. We all know that the compression ratios, as used in aviation engines, give us much higher fuel economy than those used ordinarily in automobile engines. Then why not use high compression ratios for automobile engines? We are told that higher compressions make the engine knock badly. Experience tells us that the simplest way generally accepted for getting rid of the knocking is to lower the compression ratio. The point is, shall we accept this way as final? Why not try to accomplish the same result some other way and at the same time maintain the higher economy?

We all know that an engine at full load may knock badly at 500 r.p.m. and that perhaps it will not knock at all at 1200 r.p.m. If we study the curve of brake mean effective pressure, we will find that, at 500 r.p.m., the brake mean effective pressure is greater than at 1200 r.p.m. Fig. 2, curve *B*, illustrates this. By lowering the compression to eliminate the knock, we obtain curve *A*. Suppose we go back to the higher piston compression ratio and at the same time we delay the inlet-valve timing. Experiments show that we get a brake mean effective pressure similar to curve *C*, the peak of the curve coming at a higher speed than that given by the conventional timing. The pressures at the lower speeds are reduced, which is the desired result to overcome the knocking, while the pressures at the higher speeds are materially increased.

The exact timing to use depends on the valve sizes, intake passages, carbureter characteristics and similar factors. The results obtained are more far-reaching than merely keeping the pressures within a range to eliminate the knocking at the lower speeds, and increasing the power at higher speeds. The most desirable re-

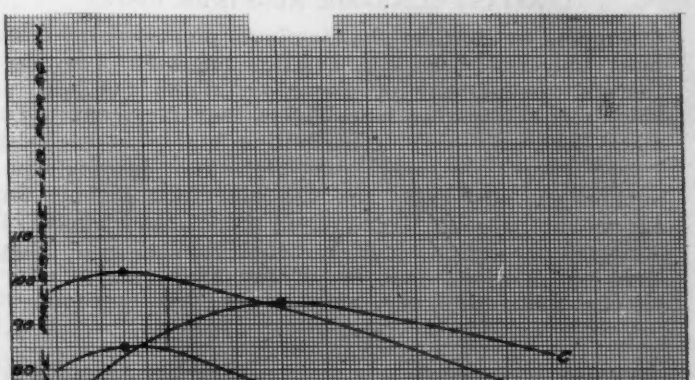


Fig. 2—Comparison of General Brake Mean Effective Pressure Curves

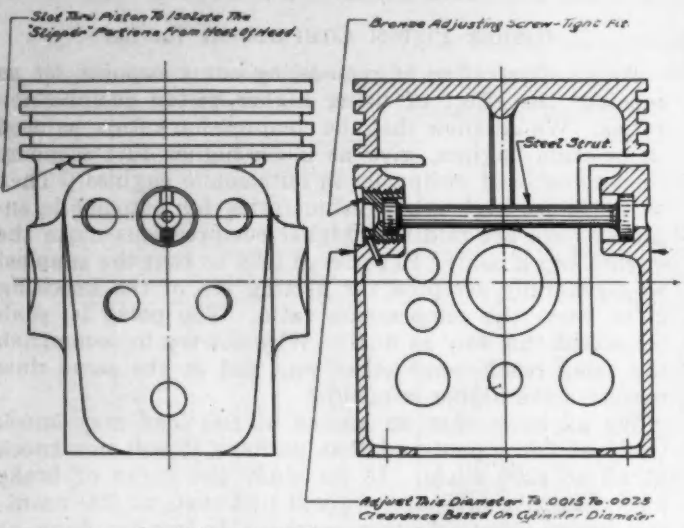


FIG. 3—A CONSTANT-CLEARANCE ALUMINUM PISTON

sults are obtained under car-driving conditions. The small charge of mixture required is taken into the cylinder and compressed to a smaller volume than in the case of the lower compression; also the charge is purer, due to the better scavenging of the higher compression pistons. The comparative tests given further on for 5 to 1 and 4.25 to 1 compression pistons at full load show increases of 13 and 24 per cent in the brake thermal efficiencies at 700 and 2100 r.p.m. respectively; while at these same speeds and at loads required by the car the increases are 22 and 41 per cent respectively. (See Figs. 29 and 30, on page 114, at 20 and 60 m.p.h. respectively.) These results are representative of only the first attempt, yet they are quite appreciable gains in economy and are due solely to the change in viewpoint on compression ratios.

CONSTANT-CLEARANCE ALUMINUM PISTON

Suppose we consider the aluminum piston, which is almost universally used in aviation engines. The high thermal conductivity of aluminum allows the heat to flow from the pistons more freely than from any other metal commonly used, contributing highly to the best known results obtained from high-speed internal-combustion engines. Why are the aluminum pistons for automobiles, though largely used, condemned by some of our leading designers of national reputation? They know the sterling qualities of the aluminum aviation pistons that make the high power and economy of aviation engines possible, yet for their automobile engines they use cast iron which perhaps could not possibly be used in the aviation engines with the high compression ratios. They tell us the trouble is that the aluminum pistons expand so much when heated that they require excessive cylinder clearance and that this allows them to slap at the lower speeds, or, if fitted closer, to stick at the higher speeds. As an alternative they select cast-iron pistons with lower compression and lower economy and greater torsional vibration of the crankshaft due to the heavier reciprocating parts and occasionally scoring the cylinder blocks. Some engineers feel, in addition, that the hotter cast-iron piston helps to vaporize the liquid fuel that comes in contact with the head of the piston.

The specific heat of aluminum is greater than that of iron, but the density of iron compared with that of aluminum gives us a heat capacity per unit volume of aluminum as being 68 per cent that of iron. This is 32 per cent in favor of the iron. However, the conductivity of aluminum is 2.85 times that of iron. From these figures it will be seen that even if the iron piston was $1\frac{1}{2}$ times as hot as the aluminum piston, the heat flow to the liquid fuel in contact with the aluminum piston-head would be about 30 per cent greater, and for same temperatures the heat flow would be about 94 per cent in favor of the aluminum. Since the aluminum piston-head usually is made thicker than that of cast iron, the amount of heat available would be approximately the same in both cases. From the foregoing it appears that the two pistons are on a par, except that heat flow is greatly in favor of the aluminum piston. The thing that seems to keep these engineers from changing their viewpoint is that it has become a habit to think that aluminum pistons must expand. Why not design an aluminum piston that cannot expand as far as cylinder clearance is concerned? This viewpoint changed the complexion of the whole problem and led to the development of aluminum automobile piston design that gives results thought to be in advance of the combined merits of the aviation piston and the cast-iron piston.

This piston is illustrated in Fig. 3. In this design the adjustable *steel* strut controls the cylinder clearance in the direction which prevents piston slap. It will be noted that the *aluminum* has nothing to do with the cylinder clearance. The strut is subject to almost the same temperature range as the cylinder; hence, the clearance remains constant through the range from a stone-cold to a steaming-hot engine. This type of piston proved very successful from the outset. It is the only type of piston, regardless of material or design, that we have not been able to make stick under abnormal conditions. It has absolutely no slapping tendencies even for a stone-cold engine. Maximum speed can be maintained on the Speedway indefinitely without causing the pistons to stick. For a more severe test the pistons were run at full load for 30 min. at 3000 r.p.m., with the radiator cooling water shut off so that the engine steamed continuously during the run (See Fig. 17 on page 109). This run was made at the end of a full day of high-speed testing with no provision for cooling the oil. The cylinder clearances of the pistons were less than those of any cast-iron pistons that we know are used in quantity production. Two of the pistons had cylinder clearances of 0.0015 in., based on the diameter. The other four pistons had clearances from 0.0020 to 0.0025 in.

In spite of all the abuse we have been able to impose on this type of piston, the pistons have always come out of the tests entirely free from any scoring marks and

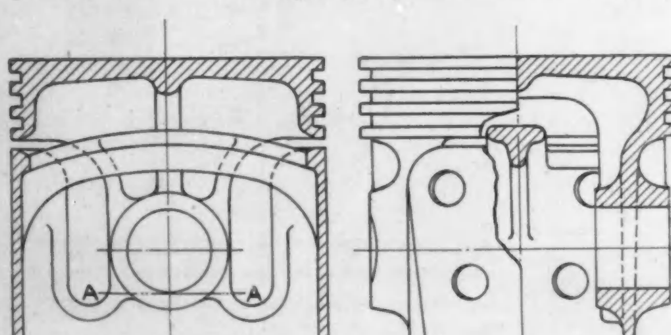


FIG. 4—ANOTHER TYPE OF CONSTANT-CLEARANCE PISTON WHICH HAS A STEEL STRUT CAST INTEGRALLY WITH THE SLIPPER PORTION

show a decided general tendency to polish-up smoother than the conventional aluminum piston. This undoubtedly follows from the maintenance of the proper clearance at all times, thus avoiding excessive bearing loading. Another striking characteristic of the pistons is their smoothness of operation, showing that even when the slap in the conventional piston is not audible there is a rumbling sound which becomes noticeable when compared with the operation of the constant-clearance piston. This difference is very marked at both high and low speeds. When the pistons are used with the conventional timing, the knock at full load and low speeds is very materially subdued compared to the conventional type of piston. This clearly shows that cylinder piston clearance has much to do with the degree of audibility of the knock.

Fig. 4 illustrates a design which has the strut cast integrally with the "slipper" portion of the piston, the latter being well insulated from the heat of the piston-head by being separated from it. The side-thrust of the piston-pin being carried by the cantilever action at section *AA*. An alternative of this design is a steel strut cast in place or fastened in some suitable manner.

Fig. 5 illustrates an aluminum piston that *contracts* when heated, so far as cylinder clearance is concerned. The steel struts in this case are shown cast in place. The reason the cylinder clearance increases with the heat on the piston is that the ends of the steel struts attached to the piston-ring-groove portion of the piston-head are carried outward, drawing the "slipper" portion inward since they are attached to the opposite ends of the struts. A large variety of designs can be made embodying the strut idea to accomplish variations of cylinder clearance, adjustment and the like, as may be desired for particular cases. It is hoped that these piston illustrations will fix the idea firmly that, so far as cylinder clearance is concerned, we have nothing to fear from the highly expansive aluminum as a piston material. As for the practical merits of the constant-clearance type of piston, they must be tried to be appreciated, because the results they give are so far in advance of one's highest expectations. The results are indeed a striking illustration of what can be accomplished by a mere change in viewpoint.

Fuel Vaporizer

Consider the general experience on exhaust-heated intake-manifolds. It is generally agreed that the results are fairly good, at the expense of a loss of maximum power due to unduly heating the air. On heating the fuel by "hot-spots," the air is also heated. The experience has been so general that it has practically fixed in our minds as an irrevocable fact that using exhaust heat necessarily must unduly heat the air. To show that this is not the fact, first let some suppositions be given which can be agreed to readily.

Suppose we run all the hot exhaust gases through a jacketed intake pipe, say some 10 in. long, to get ample surface for the "hot-spot;" that is, ample surface to transmit the exhaust heat required to vaporize the fuel, which, it has been observed, goes to the walls of the intake pipe or points of lowest air velocity. Such an intake pipe works well but it also heats the air along this surface, which is of low velocity, coming into contact with the large highly heated surface with the result that the maximum power cannot be obtained. At this point, suppose the old viewpoint of necessarily heating the air be discarded. Let us corrugate the intake-pipe surface so that the air passage is say $2\frac{1}{2}$ in. long, without reducing the area of the inner or outer surface.

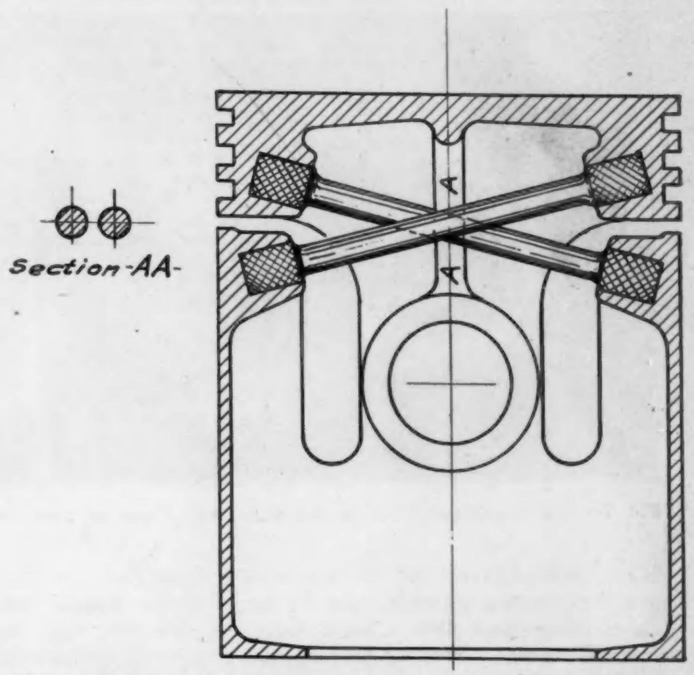


Fig. 5—A Variable-Clearance Aluminum Piston in Which the Cylinder Clearance Increases as the Piston Becomes Heated

As a practical means, materially increase the inside diameter of the intake pipe at this point and cast circular ribs on both the inner and outside surfaces. To make this clear, Fig. 6 shows a cross-section of such an intake pipe designed for the 295.2-cu. in. six-cylinder engine used in the tests to follow. Note the relatively small amount of surface exposed to the exterior of the heating chamber, which is an important item for starting out with a cold engine, and the efficient heating of the pipe at low car speeds. The heated portion of the pipe is set at an angle above the carbureter so as to

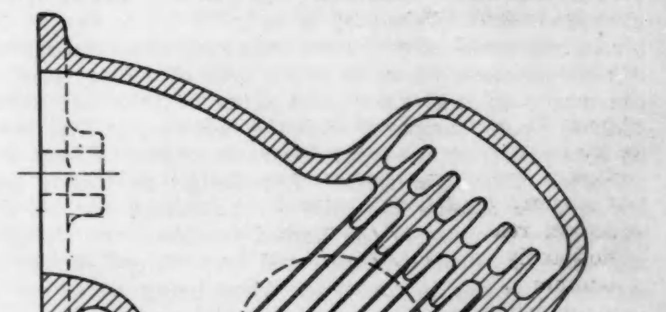


Fig. 6—Cross-Section of Intake-Pipe Fuel Vaporizer Used in the Tests

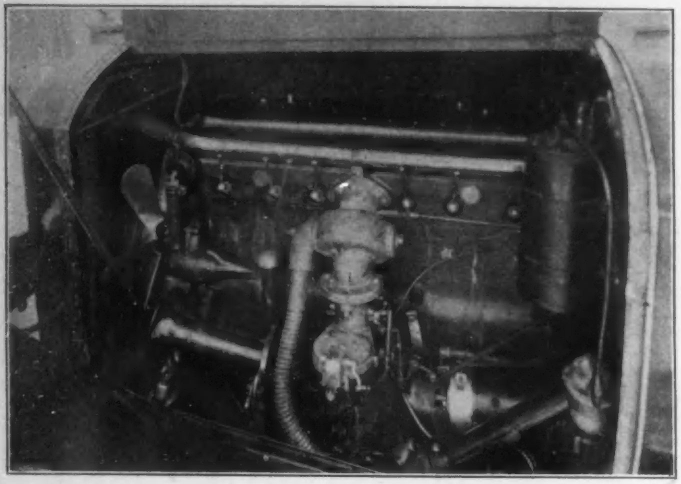


FIG. 7—THE CARBURETER SIDE OF THE ENGINE IN PLACE IN THE CAR

take advantage of the inertia of the fuel globules that may be thrown directly into the large highly heated surface. This also puts a bend into the pipe to bring the flow of liquid following the wall to the inner or smaller radius of the bend. Gravity helps to get a flow of the liquid over the heated surface. It cannot get out again into the air-stream before being highly vaporized.

The liquid fuel, while in the air-stream, seeks the walls of the pipe, as before mentioned. The highly heated corrugated surface effectively traps the fuel and quickly vaporizes and "super-heats" the vapor. Tests indicate that the air is very slightly heated while the fuel is highly vaporized. Kerosene is vaporized as readily as gasoline, even at speeds as low as 200 r.p.m. with wide-open throttle. The reason the air is slightly heated follows from the fact that only a very small portion of the air comes in contact with the edges of the ribs at the inner diameter. The actual length of the exhaust-heated intake-pipe is only 5/8 in. so far as the air is concerned. Tests have been run, *abnormally* heating the intake-pipe, with only a loss of 1.2 per cent of the power at 1200 r.p.m. and 2 per cent loss of power at 2400 r.p.m., compared with the best results that could be obtained from the most favorable degree of heat and unheated plain manifolds. The design as shown does not strictly confine the heat to the ribbed portion for practical reasons. If the heated portion were isolated, undoubtedly better results could be obtained as far as maximum power is concerned when using an excessive amount of heat.

The operation of the intake pipe in connection with the remainder of the intake passages to the cylinders has some peculiar characteristics that are very important. Off-hand it would appear as though the deep ribbing would offer a severe obstruction to the fuel passing to the cylinders. Let us compare what happens with that of the ordinary manifold where the fuel as a rule travels very much slower than the air-stream flowing along the manifold walls. A considerable time interval obtains between the time the fuel leaves the carbureter nozzle and its reaching the cylinder. In the case of the intake pipe, Fig 6, and the remaining passages to the cylinder, the heavier parts of the fuel are momentarily arrested, but they are highly vaporized quickly and pass to the cylinder at the same speed as the air-stream. Since a highly heated surface can be used without heating the air, the vapor becomes heated to a point high enough so that it does not condense while in the air-stream. Of course, the vapor going into the air-stream receives a high velocity on the outset, and the time interval for it to condense is small. Practical driving tests with and without accelerating devices verify the above explanation.

Most convincing observations are made when applying 2-in. carbureters to the engine, both on the dynamometer and on the road. For speeds below 800 r.p.m. with open throttle, the unheated plain intake-pipe could not be used at all. Even at higher speeds the economy was poor although the power was good, showing poor distribution. With the new-design intake-pipe the engine could be run to as low as 200 r.p.m. with wide-open throttle. However, this does not apply to 2-in. plain-tube carbureters that we have tried without making structural modifications in the design.

In connection with the exhaust heating of the special intake-pipe, it made it possible to equip the engine with a 2-in. carbureter. The car accelerates well in cold weather, without pulling the choker, by the time it can be driven out of a cold garage onto the street. A valve, manually operated, forces all the exhaust heat through the intake. This is used until the engine heats to the normal operating temperature, or it can be left on continuously without causing any harm except a slight restricted exhaust passage for high speed in this particular experimental design. The good acceleration while cold indicates the "super-heating" of the fuel; in other words, it does not condense materially before reaching the cylinders, even when the engine is cold. With the larger carbureter and its corresponding higher power at both low and high speeds, there also obtains a smoothness that never was obtained with smaller carbureters. The degree of flexibility, smoothness, economy and power are far in advance of the best previous results. The engine shows good torque, right down to the point of stalling. It is believed that even these preliminary investigations show that the conventional hot-spot method can be far surpassed and that the fuel can be heated without unduly heating the air. The results obtained are directly responsible to the change in viewpoint.

We will next consider tests showing the application of the correlation of car and engine characteristics using 4.25 to 1 and 5 to 1 compression pistons in the same engine. First a brief description of the basic principles of the engine and testing apparatus will be given.

FIG. 8—THE EXHAUST SIDE OF THE ENGINE

Basic Principles of the Engine

It will be of interest to emphasize some of the high lights of the engineering principles of the engine and give data that may be helpful to those that might wish to go further into details. It is a valve-in-head, six-cylinder, 3⅜ x 5½-in. engine of 295.2-cu. in. displacement. The cylinder block and upper crankcase is a one-piece casting of aluminum alloy, with inserted cylinder sleeves of cast iron machined all over. The cylinder-head is of cast iron and detachable. Fig. 7 shows the general appearance of the engine as installed in the car. Fig. 8 shows the opposite side of the engine with the side cover-plate and valve-cover removed. Fig. 9 shows a cross-section of the engine which gives a fairly good idea of the detailed construction. The crankshaft is of the three-bearing type and of liberal dimensions. The hollow crankpins are 2¼ in. in diameter and 1¾ in. long. The shaft is drilled for oil passage at 25-lb. per sq. in. pressure to all the main and connecting-rod bearings.

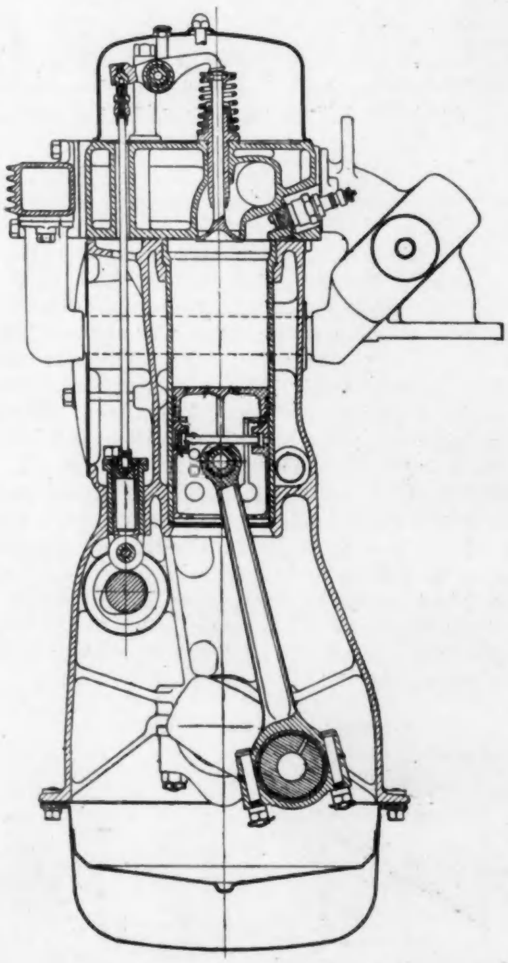


Fig. 9—Cross-Section of the Engine

Attention is called to the unique cylinder-sleeve construction with particular reference to the application of the packing at the bottom of the sleeve. The sleeve at the bottom diameter has a snug slip fit in the aluminum case. The sleeve, however, has been shown to have a very slight axial movement here. This follows from the fact that the aluminum case is not subject to as high a temperature range as the cast-iron sleeve, the higher coefficient of expansion of the aluminum being offset by the greater temperature range of the sleeve. The pressure on the combination cork and hydroil packing is in an axial direction only; that is, there are no radial components of pressure from the reactions of the packing to throw the sleeve out of round. This is the characteristic difference from other types of sleeve constructions and is the basic principle making the installation of a sleeve construction successful.

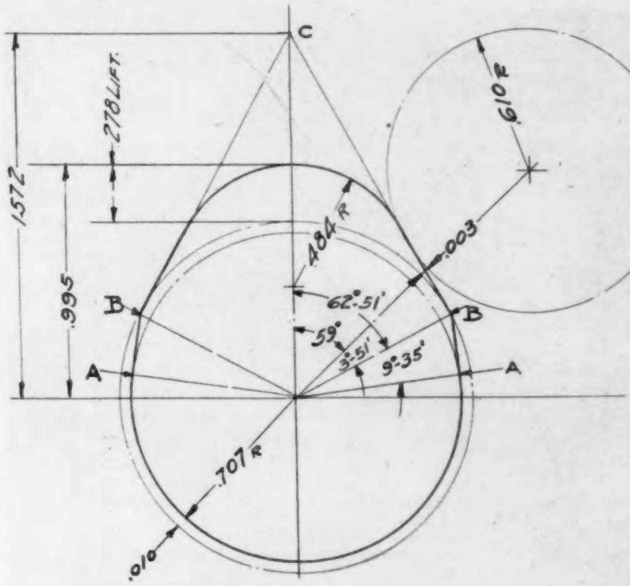


Fig. 10—Details of the Inlet and Exhaust Cams

The Exhaust Cam Leads the Inlet by 118 Deg. *AB* and *BC* Are Straight Lines Intersecting at a Sharp Angle at *B*

Fig. 10 gives the details of the inlet and exhaust cams, both cams being identical. Fig. 11 gives the flywheel timing diagram for a valve-stem end-clearance of 0.0212 in.; however, the operating valve-stem clearance is 0.015 to 0.017 in. This is a special type of cam having a zero opening and closing valve velocity regardless of engine speed. A detailed description and mathematical analysis of this type of cam will be found in the 1917 S. A. E. Transactions, Part 1, pages 328 to 337. Fig. 12 on page 108 gives the valve-mechanism characteristic curves for an engine speed of 3000 r.p.m. Attention is called to the design to obtain a high acceleration away from the cam and a low acceleration toward the cam; that is, the acceleration that must be produced by the valve spring to keep the

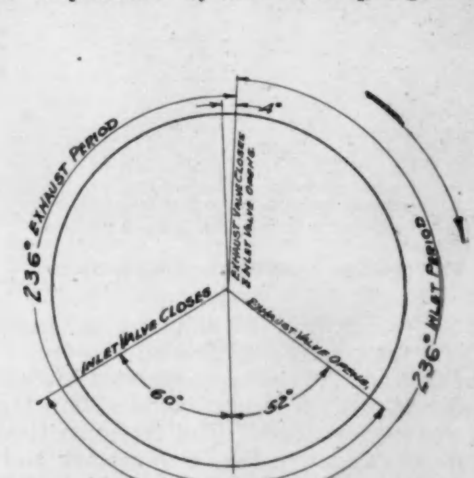


Fig. 11—Flywheel Timing Diagram for Checking Assembly of Camshaft in Engine

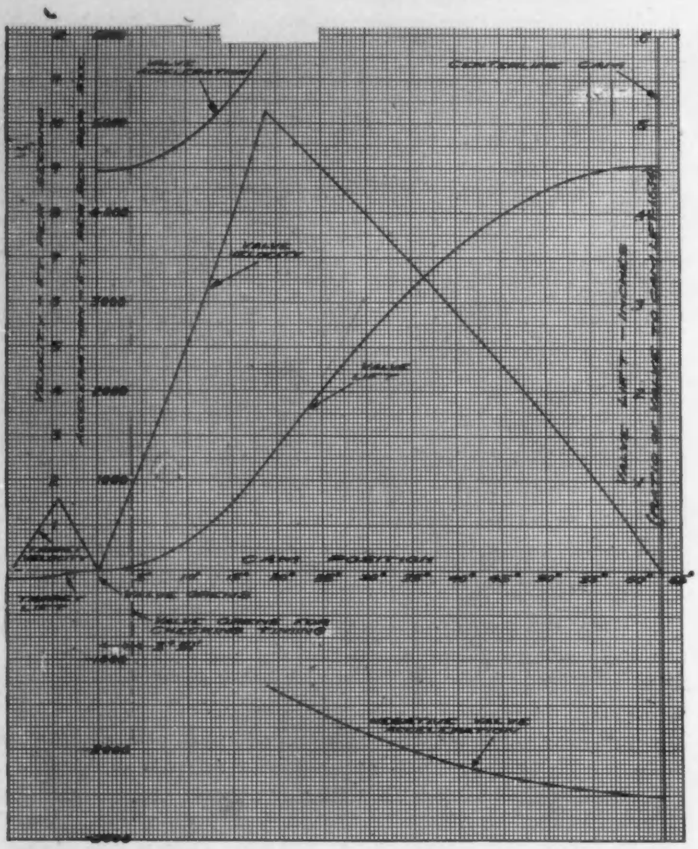


FIG. 12—VALVE-MECHANISM CHARACTERISTIC CURVES AT AN ENGINE SPEED OF 3000 R.P.M.

roller following the round peak of the cam, the 0.484 R shown in Fig. 10 on page 107. The equivalent weight of all the accelerated parts considered placed at the valve is 0.7635 lb. The valve-spring pressure required at 3000 r.p.m. is 59.8 lb. per sq. in.; at 3200 r.p.m. it is 68 lb. per

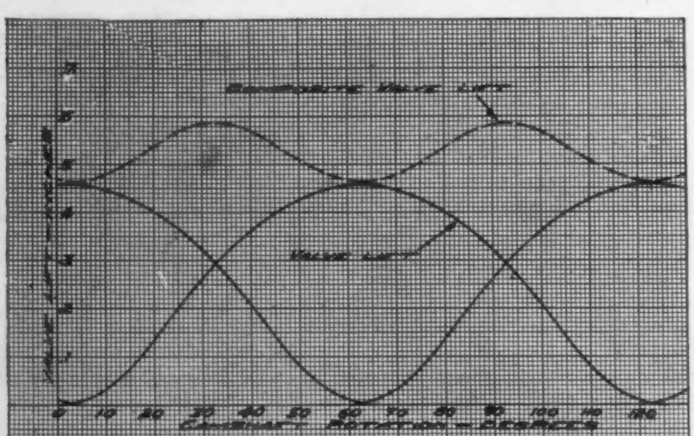


FIG. 13—THE INLET-VALVE TIMING OVERLAP

sq. in.; at 3400 r.p.m. it is 76.8 lb. per sq. in. Great care is taken to have the master cam ground to a true radius at the peak of the cam. If the cam generated has any bumps on the peak radius, it is impossible to obtain high-speed operation for two reasons. The irregularities set up synchronous vibrations in the valve springs and the accelerations are immensely increased, making the springs too weak. For instance, if the 0.484-in. peak-radius has waves on it of 3/16-in. radius, the acceleration is increased 116 per cent. These points are mentioned because they are absolutely vital to the successful application of the valve mechanism of the roller type to a valve-in-head engine operated at high speeds.

Fig. 13 gives the inlet-valve timing overlap. This diagram shows that although the inlet-valve is held open fairly late, the valve of another cylinder is close to its maximum lift, preventing a blow-back into the carbureter.

Fig. 14 shows a diagram of the intake-manifold passages. These are cast within the cylinder-head, mak-

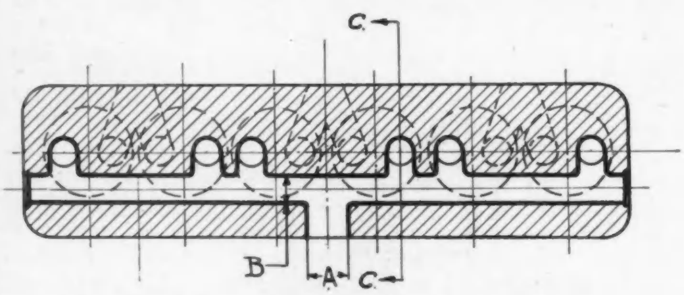


FIG. 14—DIAGRAM OF THE INTAKE-MANIFOLD PASSAGES

ing them of the shortest possible design. The engine cylinders fire in the order of Nos. 1, 5, 3, 6, 2 and 4; therefore, the flow of gas is continuous in both directions from the center. The average gas velocity at 3000 r.p.m. at A is 181 ft. per sec.; at B it is 175 ft. per sec.; just above the valve it is 192 ft. per sec. and at full lift of the valve it is 247 ft. per sec. The throat diameter of the valve is 1½ in.; the outside diameter is 1⅝ in.; the valve lift is 0.445 in. The area at B, Fig. 14, is 1.75 sq. in. and at A it is 3.39 sq. in. The tulip-shaped inlet-valve is used to lessen the resistance and keep the velocity of the gas as high as possible on entering the cylinder as an aid to turbulence.

The intake-pipe has already been described as shown in Fig. 6, on page 105. The application to the engine in the preliminary experimental form is shown in Figs. 7 and 8 on page 106.

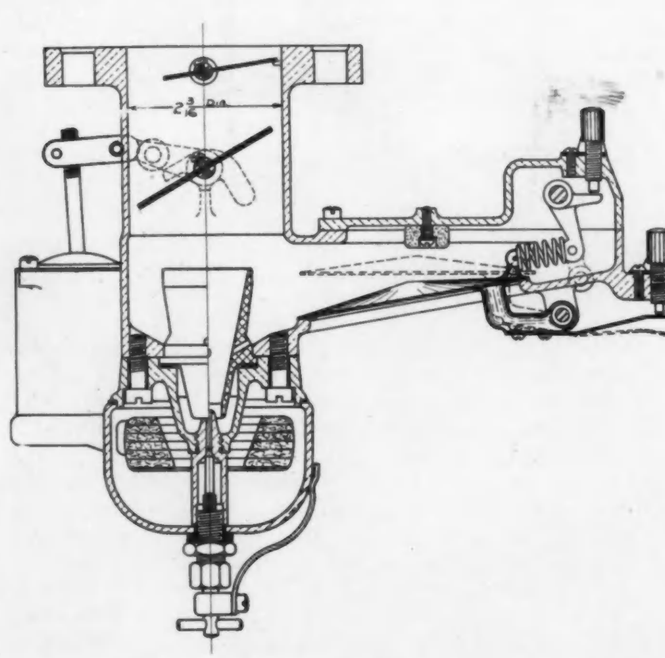


FIG. 15—CROSS-SECTION OF THE CARBURETER USED IN THE TESTS

Fig. 9 on page 107 shows the passage of the exhaust-gas pipe between the two center cylinders and the gas outlet pipe as used in the tests is shown in Fig. 19, on page 110, the valve at the end of the pipe being left wide open for all the runs. The engine is equipped with a Delco generator and single breaker-point type of ignition, with automatic and manual spark advance. A Willard battery was charged during the tests and also was used for starting. The spark-plug installation is shown in Fig. 9. Champion—Toledo No. A-63 metric two-piece plugs were used for all the runs. The perfect operation of these plugs had much to do with the ease with which the tests were run. Only six plugs were used and at the end of the runs they were in perfect condition. This is saying a great deal

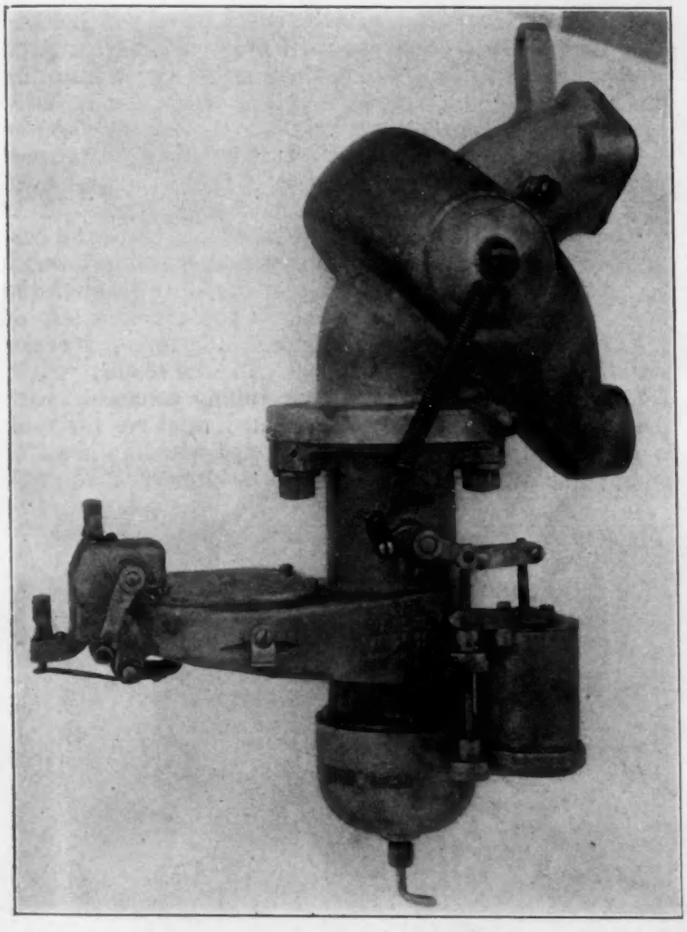


FIG. 16—THE INTAKE-PIPE FUEL VAPORIZER AND CARBURETER SHOWING THE KNURLED THUMBSCREW AND LOCK-NUT EMPLOYED TO ADJUST THE THROTTLE OPENING REQUIRED FOR THE PARTIAL LOAD TESTS CORRESPONDING TO THE CAR REQUIREMENTS

for the spark-plugs, considering the high-compression pistons, power output and speed of this engine.

Fig. 15 shows the 2-in., Johnson, Model-B carbureter used. The air-valve spring and strangle tube were first worked out for the low-compression piston tests. The same parts worked out nicely in connection with the 5 to 1 compression pistons, with only a slight change of adjustment on the air-valve spring. Otherwise, in each set of tests, all adjustments were kept constant for both partial and full-throttle loads.

Fig. 16 shows the knurled thumbscrew and lock-nut used to adjust the throttle opening required for the partial load tests corresponding to the car requirements. The spring shown kept the slack out of the throttle shaft. With the Sprague electrical dynamometer and the fine

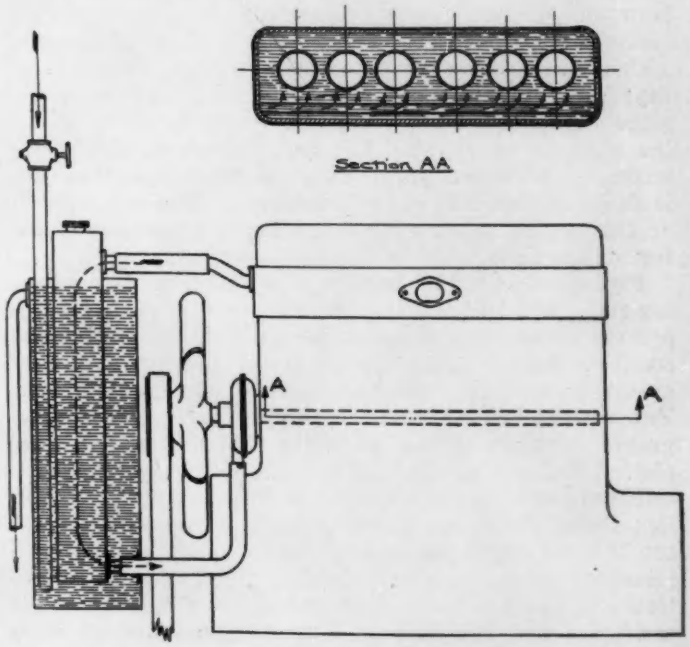


FIG. 17—DIAGRAM OF THE ENGINE COOLING-WATER CIRCULATION AND THE RADIATOR COOLING SYSTEM

throttle adjustment, the proper load and speed were obtained readily.

The section at *AA* in Fig. 17 shows the equal distribution of the cooling water to the cylinder sleeves. The water goes from the pump to the tube inside the cylinder block. Two holes for each sleeve give a uniform distribution of the water. This keeps all the sleeves at the same temperature, an important feature for equal gas distribution and smooth running. The engine cooling water circulates through a standard radiator as used

FIG. 18—THE CONNECTING-ROD, INLET-VALVE, EXHAUST-VALVE, PISTON-PIN AND PISTONS

on the car. The radiator is cooled by circulating water from an outside source around the outside of the radiator; that is, the cooling medium is water in place of air as used in the car. However, the engine water, having the same resistance as in the car, must have the same temperature drop, for the quantity circulated is the same in each case. The temperature of the engine water is controlled very easily by this apparatus, and is an exact duplicate of car conditions. The temperature of the engine water outlet was kept at 150 deg. fahr. for all the tests.

Fig. 18 on page 109 shows a photograph of the connecting-rod, inlet-valve, exhaust-valve, piston-pin and the pistons. The connecting-rod length is 11 in., the weight complete with bearings is 46.35 oz. and the center of gravity is 2.60 in. from the center of the crankpin end. Two pistons are shown at the upper part of the photograph. The one to the left is the 4.25 to 1 compression piston; the one to the right is the 5 to 1 compression constant-clearance type of piston. The view at the bottom shows the latter piston from a different angle. A set of 4.25 to 1 compression pistons of the constant-clearance type was not available for the comparative tests; however, 1/8-in. wide piston-rings were used in each case and the 4.25 to 1 compression pistons were relieved at the side in an endeavor to give the pistons approximately the same bearing area as the other pistons. The cylinder clearance given the low-compression pistons was 0.005 to 0.006 in. and that of the high-compression pistons 0.0015 to 0.0025 in. The weight of three 1/8-in. wide piston-rings is 1.82 oz.; that of the 4.25 to 1 piston, 13.52 oz.; that of the 5 to 1 piston, 18.65 oz.; and that of the piston-pin, 5.60 oz. The weight of the complete engine without the clutch is 660 lb. The weight of the complete powerplant, engine, clutch and transmission is 780 lb.

Testing Apparatus

Fig. 19 shows the Sprague dynamometer equipment. A Weston tachometer was used to indicate the speed. This was checked repeatedly by a revolution counter throughout the entire range of speeds used. The engine cooling-water temperature was obtained by a radiometer calibrated for the range used. The temperature control of the engine cooling water has already been described, and a diagram of it is shown in Fig. 17 on page 109. Fig. 19 shows also a view of the radiator installed within the cooling tank.

Particular care was used in weighing the fuel for each run. Two fuel tanks were used, one for a general supply and the other for weighing the fuel consumed in 120 sec. The time interval was obtained from the second hand of a watch and the use of a three-way valve connecting the two tanks to the carbureter. Both tanks were equipped with gage glasses so that the level of gasoline could be kept almost the same. This is important because the height of the level of gasoline in the carbureter bowl is a function of the pressure on the gasoline. It is obvious that, should the level of the gasoline in the carbureter change during the run, the fuel weighed would be in error by the amount of fuel it took to change the level. The main tank is shown at the extreme left of Fig. 19 and the weighing tank and Fairbanks silk scales are shown in Fig. 20. This scale balances readily within 1/100 oz., even when the rubber tubing connected with the fuel line is in place. The small line above the tank is for filling purposes and is connected with the gasoline pump that draws the fuel from the underground tank

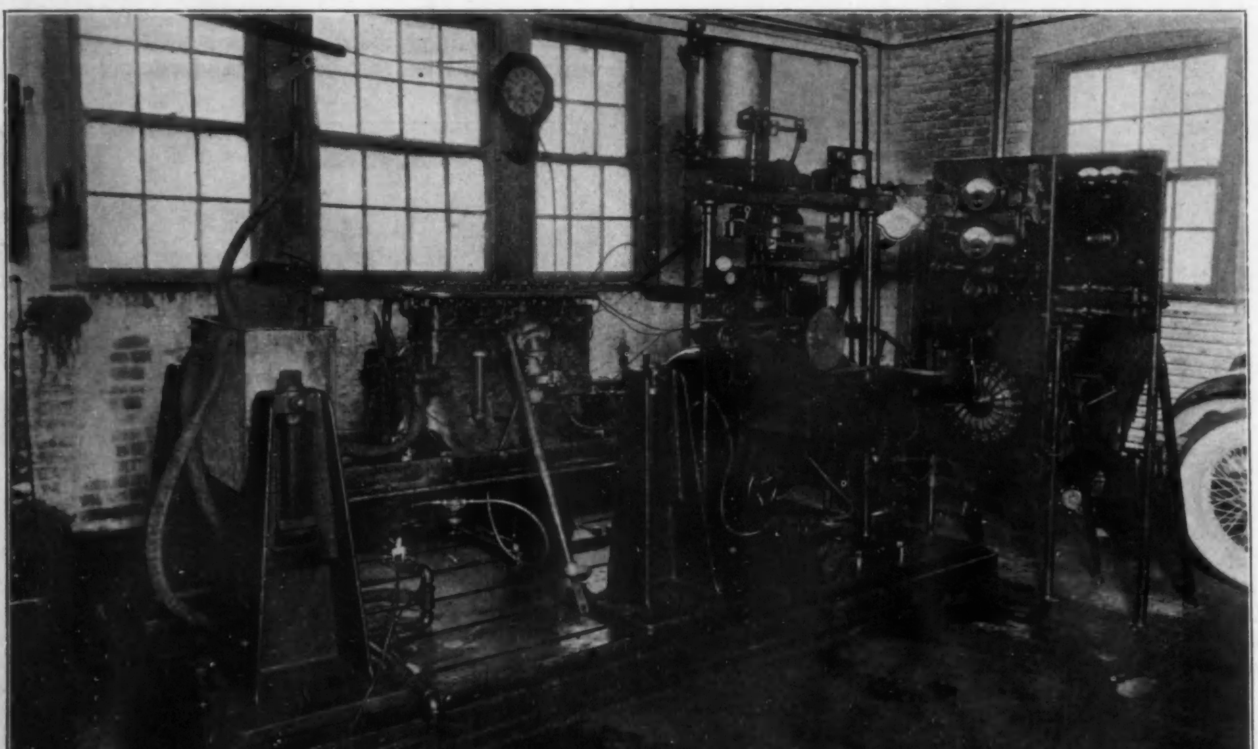


Fig. 19—Dynamometer Equipment Used

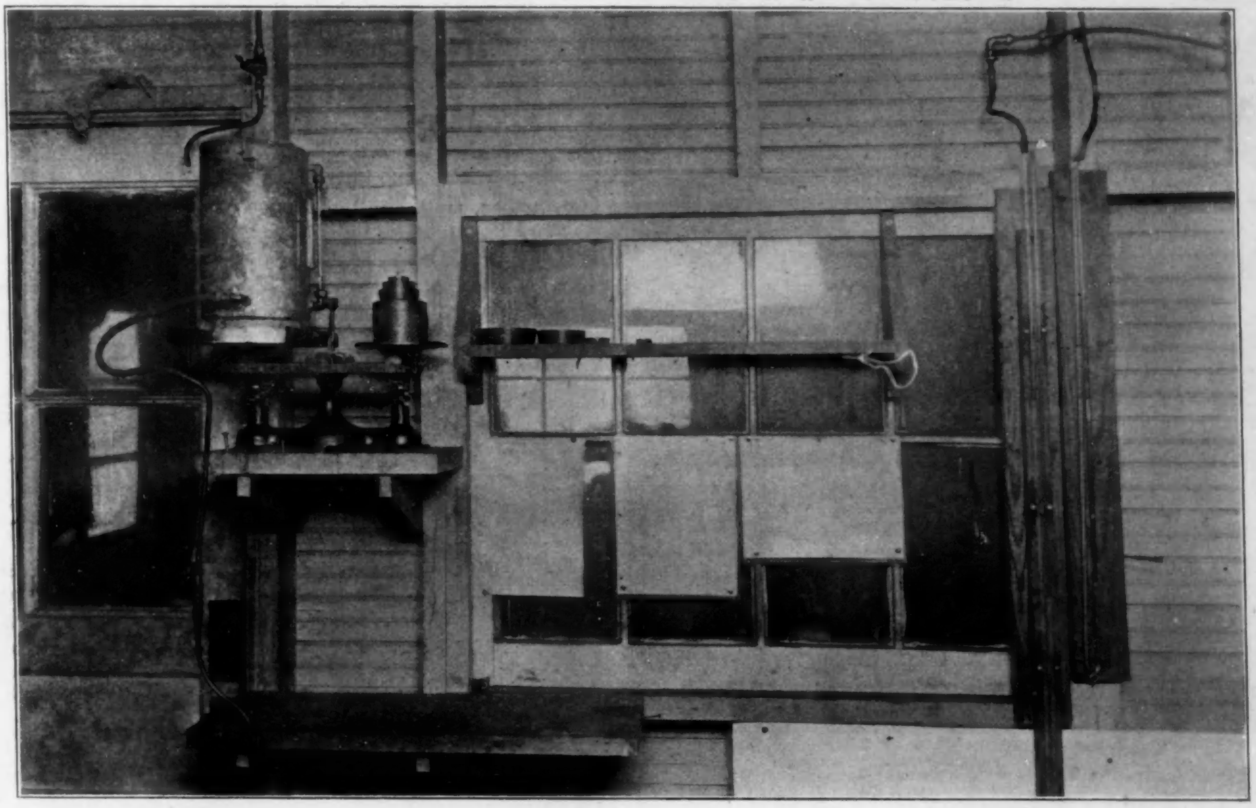


Fig. 20—Fuel Weighing Scales and Manometers

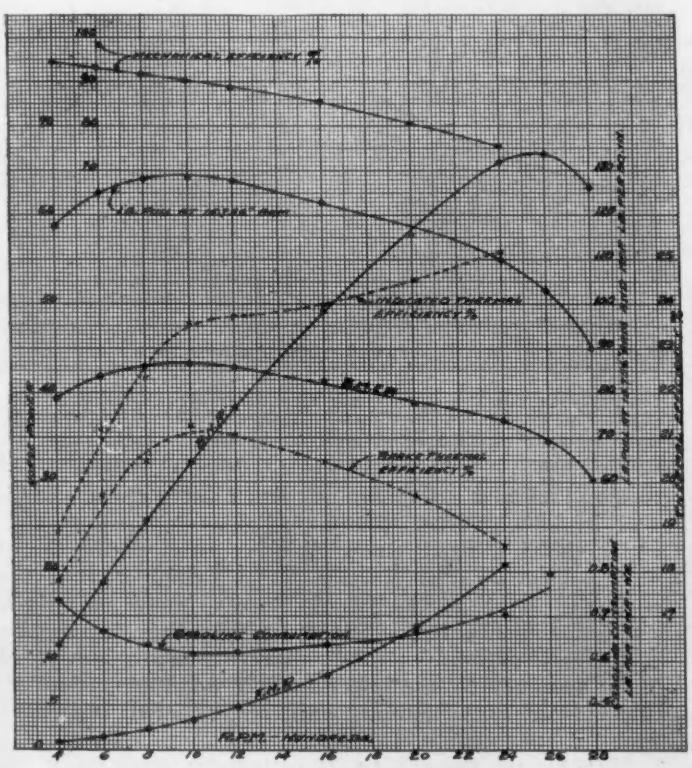


Fig. 21—Engine Characteristic Curves Obtained with an Open-Throttle and Pistons Having a Compression Ratio of 4.25 to 1

outside the laboratory. At the right of Fig. 20, the mercury and water manometers are shown. These are connected to the intake-pipe on the engine.

During the tests the windows of the laboratory were opened and the room temperature kept close to 65 deg. fahr. on all the runs. The average barometer readings for comparative tests Nos. 1 and 5 were 30.23 and 30.22 in. of mercury respectively. (See Figs. 21, 24 and 29 on pages 11, 12 and 14.) The oil used in the tests was Mobiloil "A." The gasoline used was Target brand, made by the Western Oil Refining Co. The weight of a sample gallon was 96.80 oz. and the heat value per pound was taken as 19,500 B.t.u. in connection with the calculation of the thermal efficiencies.

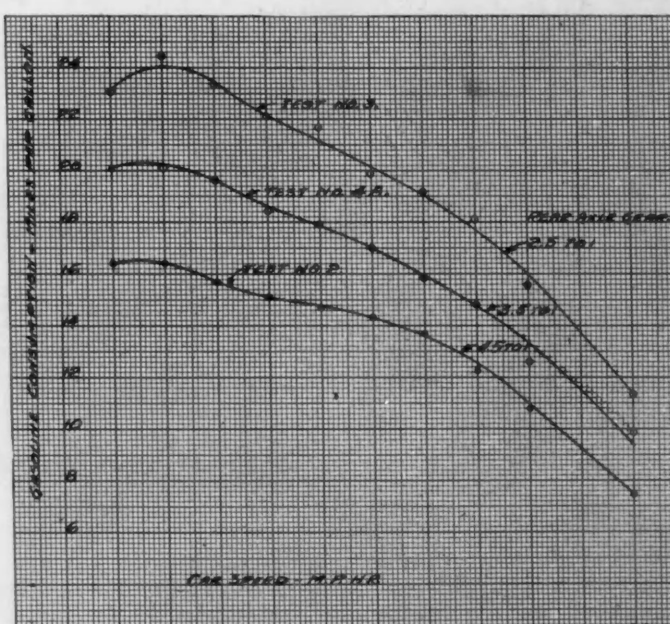


Fig. 22—Curves Showing the Relation Between Car Speed and Fuel Consumption Using Pistons Having a Compression Ratio of 4.25 to 1

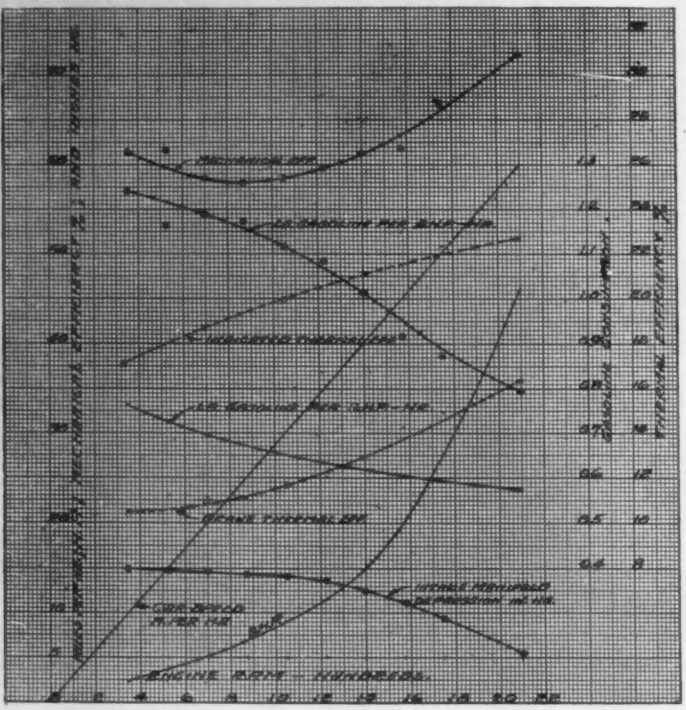


FIG. 23—ENGINE CHARACTERISTIC CURVES OBTAINED WITH A CONSTANT CAR SPEED, A 3.5 TO 1 REAR-AXLE GEAR-RATIO AND PISTONS HAVING A COMPRESSION RATIO OF 4.25 TO 1

COMPARATIVE TESTS

Some of the characteristics of the tests will first be mentioned and then curves will be shown giving the percentage comparison of results. Fig. 21 on page 111 shows the engine characteristics at full load with the 4.25 to 1 compression pistons. The maximum brake mean effective pressure comes at 1000 r.p.m., with a considerable reduction at 400 r.p.m. due to the delayed inlet-valve timing. The maximum fuel economy is 0.613 lb. per b.hp. per hr. The mechanical efficiency is very good at low speed but drops off rather fast as the speed increases. The peak of the power curve is at 2600 r.p.m.

Fig. 22 on page 111 shows the results of tests Nos. 2, 4A and 3, in terms of miles per gallon for 4.5, 3.5 and 2.5 rear axle gear ratios and 4.25 to 1 compression pistons. It will be noticed that a material increase in mileage is obtained as the engine load factor is increased by changing the rear-axle gear-ratio.

Fig. 23 gives the engine characteristic under constant-speed driving conditions with 4.25 to 1 compression pistons and 3.5 to 1 axle gears. It will be seen that the full-load brake characteristics have been changed greatly, while the indicated characteristics have suffered but little. The so-called friction losses, which include the pumping and thermodynamic losses, very materially lower the mechanical efficiency. Note that the engine is pumping against an intake-manifold depression of 15 in. of mercury at the lower speeds and the mechanical efficiency at 800 r.p.m. is only 58 per cent, compared with 91.7 per cent at full load.

Fig 24 gives the engine characteristic when using the 5 to 1 compression pistons, everything else on the engine being identically the same. The readings given are not "snap" readings. The engine in all tests was kept running continuously and the results shown are those at which the engine runs with stability; that is, the result to which the engine settles at any given speed. It will be noticed that the maximum brake mean effective pressure is still at 1000 r.p.m., but it has increased from

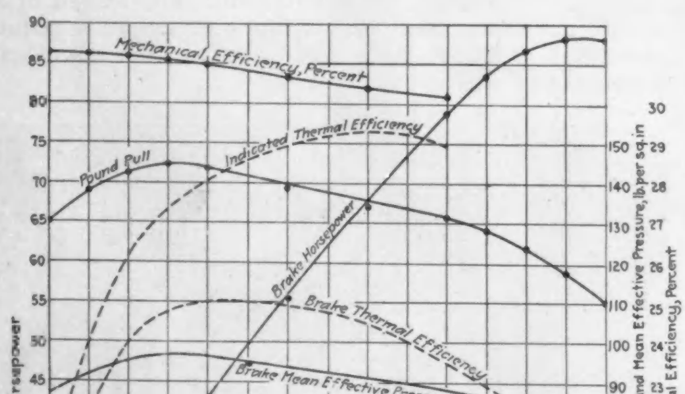


FIG. 24—ENGINE CHARACTERISTIC CURVES OBTAINED WITH OPEN THROTTLE AND PISTONS HAVING A COMPRESSION RATIO OF 5 TO 1

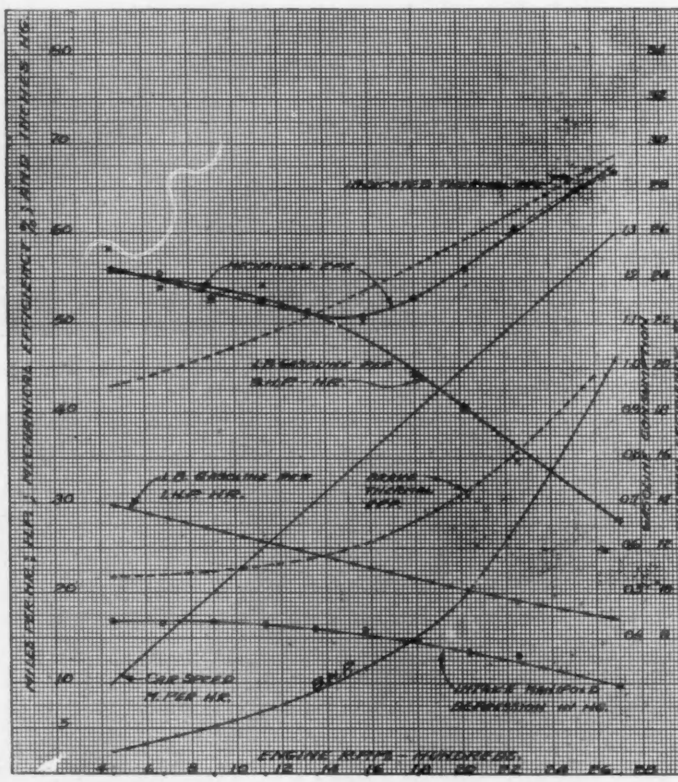


FIG. 25—ENGINE CHARACTERISTIC CURVES OBTAINED WITH A CONSTANT CAR SPEED, A 4.5 TO 1 REAR-AXLE GEAR-RATIO AND PISTONS HAVING A COMPRESSION RATIO OF 5 TO 1

86.2 to 96.9 as compared with Fig. 21 on page 111. It will also be noticed that the increase is greater as the speed increases. The peak of the power curve comes at about 3100 r.p.m. The fuel economy is greatly increased being 0.527 lb. per b.hp. per hr. at 1000 r.p.m. as compared to 0.613 lb. per b.hp. per hr. in the case of 4.25 to 1 compression. The mechanical efficiency is shown as not being as good below 800 r.p.m., but it is very much better at the high speeds, being 76.1 per cent as compared with 81.4 per cent at 2400 r.p.m. The

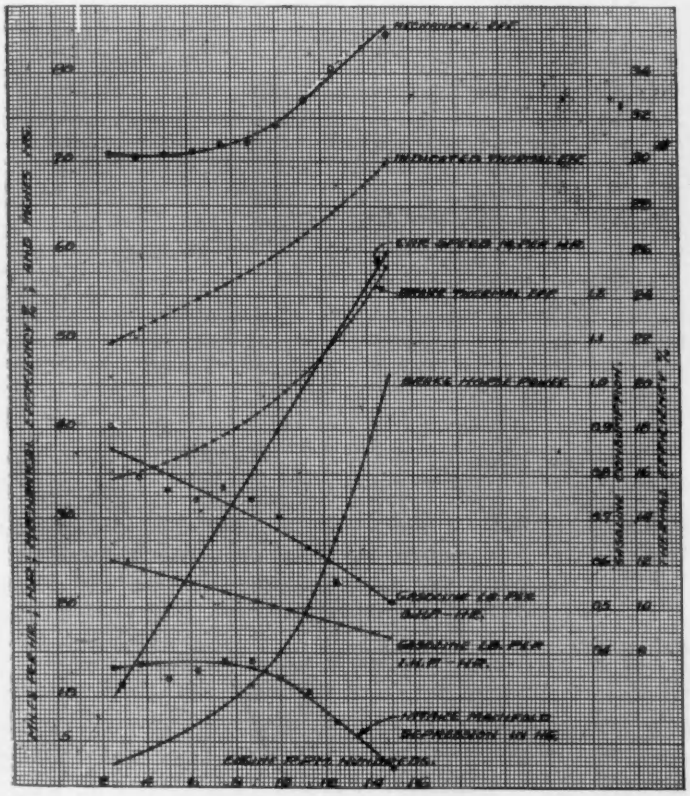


Fig. 26—Engine Characteristic Curves Obtained with a Constant Car Speed, a 2.5 to 1 Rear-Axle Gear-Ratio and Pistons Having a Compression Ratio of 5 to 1

maximum brake thermal efficiency is increased from 21.1 to 24.8 per cent.

Fig. 25 gives the engine characteristics in connection with constant-speed driving, with 5 to 1 compression pistons and 4.5 to 1 axle gears. Fig. 26 is for 2.5 to 1 and Fig. 27 is for 3.5 to 1 axle gears. Fig. 27 can be compared directly to Fig. 23, the only difference being the compression ratios. It will be noticed that the mechanical efficiency has not been materially changed; however, the fuel economy has been very materially increased. It is very gratifying to note that the relative increases are even greater than those of full-load characteristics. At 1000 r.p.m., the brake thermal efficiency has been increased from 11.5 to 14.1 per cent, and at 2100 r.p.m. it has been increased from 16.4 to 23.2 per cent.

Fig. 28 shows the miles per gallon curves for 5 to 1 compression pistons. This can be directly compared to Fig. 22. The results are materially higher all along the line. The overall increase at 15 m.p.h. is from 16.4 to 31 miles per gal., when changing both the compression and the axle gears.

In reference to what these curves represent, compared with actual roads tests, on long road tests the results agree very closely with the curves considering the

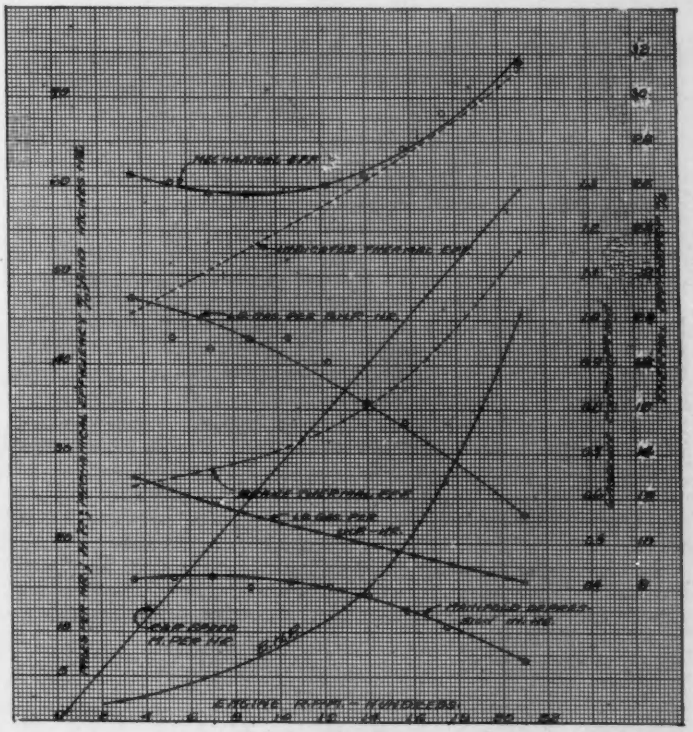


Fig. 27—Engine Characteristic Curves Obtained with a Constant Car Speed, a 3.5 to 1 Rear-Axle Gear-Ratio and Pistons Having a Compression Ratio of 5 to 1

amount of time the engine is idled and the nature of the driving. On the speedway, however, the results can be duplicated at constant driving. They also can be increased in case of using light engine oil and higher tire

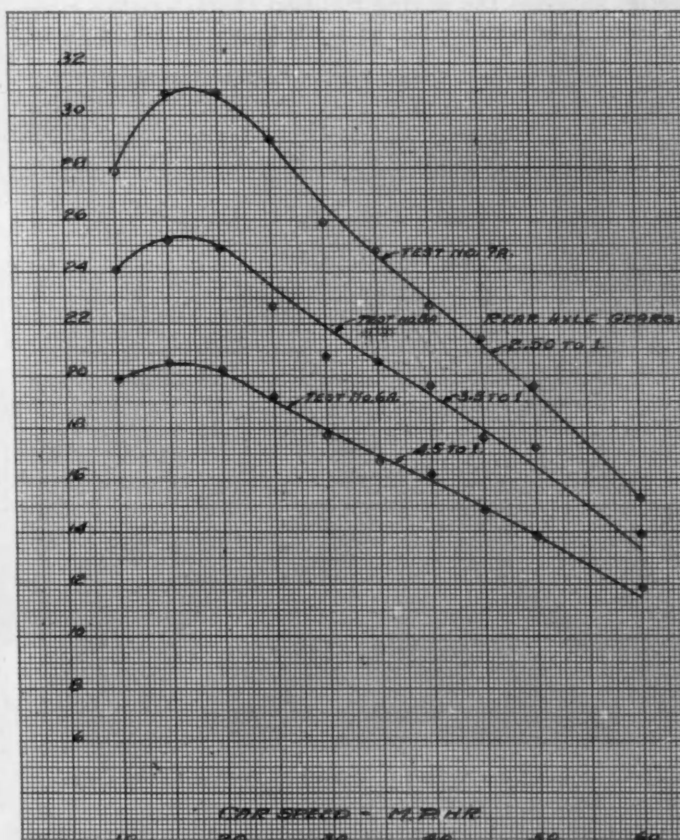


Fig. 28—Curves Showing the Relation Between Car Speed and Fuel Consumption Using Pistons Having a Compression Ratio of 5 to 1

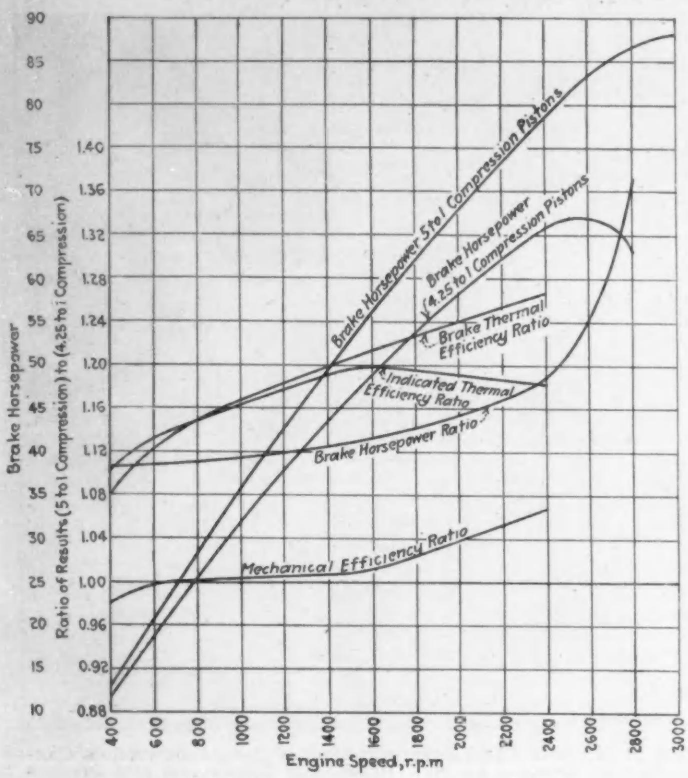


FIG. 29—A COMPARISON OF THE ENGINE FULL-LOAD CHARACTERISTICS

pressure than those used in the tests to set the standard of brake horsepower required.

PERCENTAGE COMPARISON OF RESULTS

Fig. 29 gives the engine full-load characteristics comparison. The comparison as a whole is entirely in favor

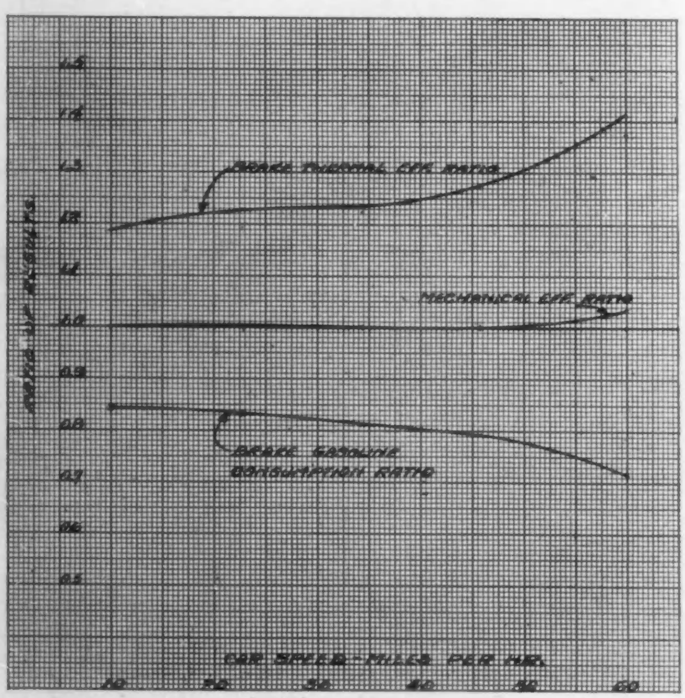


FIG. 30—A COMPARISON OF THE COMPRESSION RATIOS USING A REAR-AXLE GEAR-RATIO OF 3.5 TO 1

of the higher compression ratio, except a very slight loss in mechanical efficiency below 800 r.p.m. The increase in brake horsepower is marked, especially at the higher speeds. The percentage increase in power ranges from 10.5 to 37 per cent, between 400 and 2800 r.p.m. The most important increase is that of the brake thermal efficiency. This ranges from 8 to 26 per cent.

Fig. 30 gives the comparison of the compression ratio when keeping the rear-axle gears the same; namely, 3.5

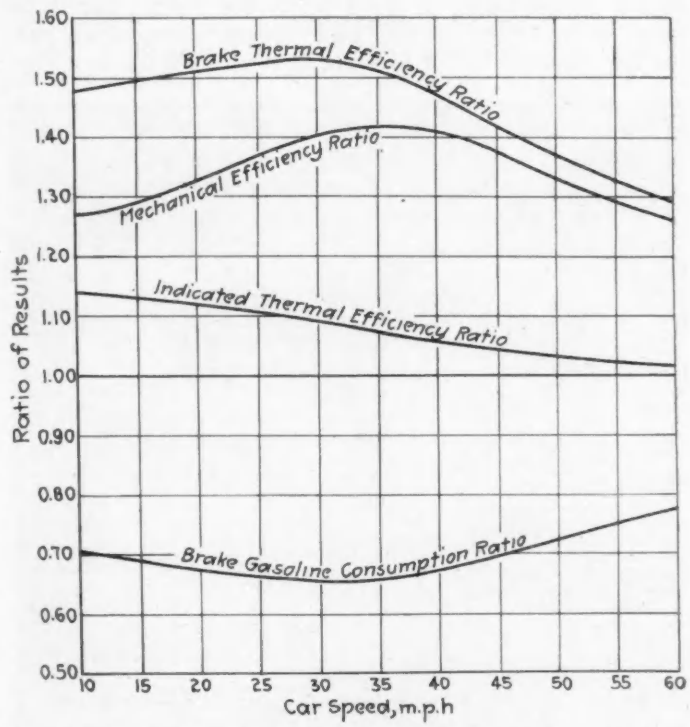


FIG. 31—COMPARISON OF REAR-AXLE GEAR-RATIOS USING PISTONS HAVING A COMPRESSION RATIO OF 5 TO 1

to 1. The mechanical efficiency remains practically the same, due to identical engine speeds in each case. The increase in brake thermal efficiency ranges from 19 per cent at 10 m.p.h. to 41 per cent at 60 m.p.h. The saving in gasoline is from 16 to 28 per cent, and, at average driving speed, about 18 per cent.

Fig. 31 gives the comparison of the rear-axle gear-ratios of 2.5 to 1, and 4.5 to 1, using 5 to 1 compression pistons. The percentage increase in mechanical effi-

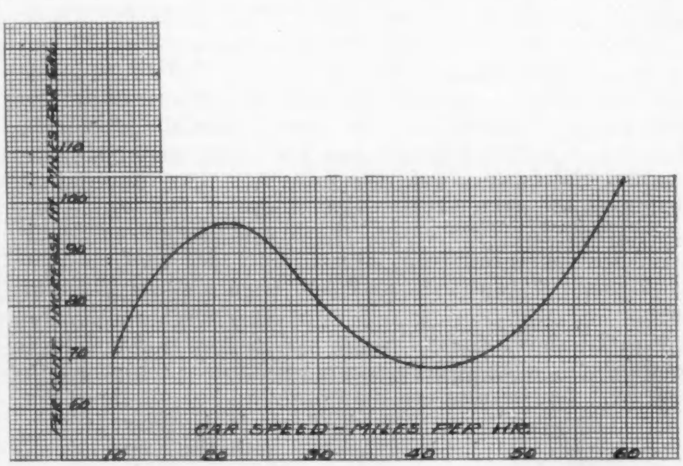


FIG. 32—PERCENTAGE INCREASE IN MILES PER GALLON OF FUEL USING A REAR-AXLE GEAR-RATIO OF 2.5 TO 1 AND PISTONS HAVING A COMPRESSION RATIO OF 5 TO 1 AS COMPARED WITH A REAR-AXLE GEAR-RATIO OF 4.5 TO 1 AND PISTONS HAVING A COMPRESSION RATIO OF 4.25 TO 1

ciency is very marked; the maximum gain is 42 per cent at 36 m.p.h. At 10 m.p.h. it is 27 per cent and at 60 m.p.h. it is 26 per cent. The maximum increase in the brake thermal efficiency is 53 per cent, at 29 m.p.h. It is 48 per cent at 10 m.p.h. and 29 per cent at 60 m.p.h. The gasoline saved is 30 per cent at 10 m.p.h.; 34 per cent at 29 m.p.h.; and 23 per cent at 60 m.p.h.

Fig. 32 gives the percentage increase in miles per gallon in the case of using 2.5 to 1 axle gears with 5 to 1 compression pistons, compared to 4.5 to 1 axle gears and 4.25 to 1 compression pistons. The increase in miles per gallon is 70 per cent at 10 m.p.h.; 95 per cent at 20 m.p.h.; 81 per cent at 30 m.p.h.; 68 per cent at 40 m.p.h.; 76 per cent at 50 m.p.h.; and 104 per cent at 60 m.p.h. These are indeed increases in economy that cannot be passed by lightly, yet they are by no means as great as the economy that is possible. Let us next consider the economy that is possible even with our present engines. For the sake of a name let us call it the "Ideal" economy.

Ideal Economy

We are a long way from the point where we utilize even the economy that is in our present engines. Fig. 33 gives a comparison which throws some light on what is meant. This chart is based on the actual engine economy existing at 60 m.p.h. when using 2.5 to 1 axle gears and 5 to 1 compression pistons. The economy is 0.513 lb. per b.hp. per hr. Using this economy and the brake horsepower required to drive the car at each speed, we derive a curve that we have termed the "Ideal" economy in terms of miles per gallon. It is not meant that this curve is practical with our present system of transmission of the power, but, if the proper gear ratio and engine size are used for any given speed, this economy can be obtained for the size of car used in these tests. From the ideal curve it will be seen that it is possible to get 49 miles per gal. at 10 m.p.h.; 45 at 20 m.p.h.; 39 at 30 m.p.h., and 31 at 40 m.p.h. The comparison is made with the results of 2.5 to 1 and 4.5 to 1 axle gears, in connection with the 5 to 1 compression pistons.

The increase in the miles per gallon over that of the results with 2.5 to 1 axle gears is 76 per cent at 10 m.p.h. and 45 at 30 m.p.h. The increase over that of the results of 4.5 to 1 axle gears is 146 per cent at 10 m.p.h., 115 per cent at 30 m.p.h. and 36 at 60 m.p.h. Further, the ideal economy comparison with the results obtained from 4.5 to 1 axle gears and 4.25 to 1 compression pistons is an increase of 104 per cent at 60 m.p.h.; 163 per cent at 30 m.p.h., and 199 per cent increase in miles per gallon at 10 m.p.h. These figures certainly are emphatic enough to arouse several changes in viewpoint of our present methods of applying our engines. Evidently there is room for very considerable progress and it is hoped it will be forthcoming in the near future.

It is hoped that the example of correlating important data will be carried out thoroughly in all our engineering investigations, thereby enlarging our viewpoint. Means should be developed making it possible to use very high piston compression ratios. It is felt certain that it can be done and to a great advantage from the point of economy. It is hoped that very decided progress will be attempted in piston development with a view to overcoming knocking and increasing the general efficiency.

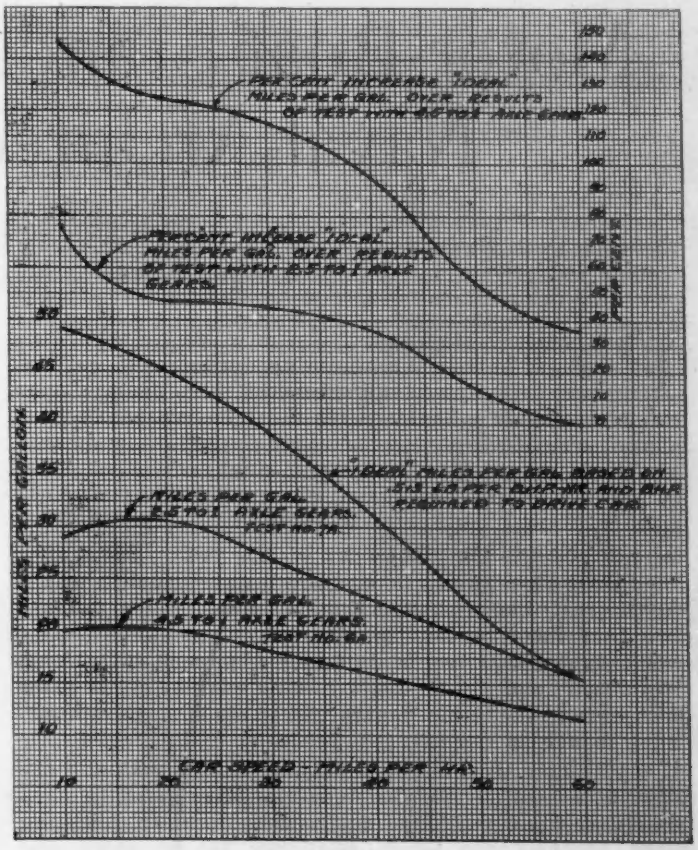


Fig. 33—A Comparison of the Economy That Is Possible with Present Engines Compared with the Results Obtained in the Tests

Our viewpoints on fuel vaporizers will, it is hoped, be greatly augmented and, as engines are made smaller to increase the load factor, carbureters will be made larger to avoid pumping losses and loss of maximum power. The fallacy that large carbureters are not as flexible or as economical as small ones is based, it seems, on the failure of certain types of large carbureter which it is thought are working on incorrect principles. It is recommended that we test the idea of using large carbureters to operate small engines, rather than that of using large engines to operate small carbureters.

The application of the indicated engine power should be studied from every angle. The tests show that an absurd waste is rampant in our present method. How far our ingenuity can go in this direction is hard to predict. One thing is certain, we must analyze carefully the gains that can be made. A close study from the brake-horsepower standpoint may justify changing both our transmission and our rear-axle drives. The latter combinations, together with engine developments, look the most promising at present. The progress we make undoubtedly will be measured by the extent to which we expand our engineering viewpoint.

Motor-Boat Standardization from the Naval-Architect's Viewpoint

By William J. Deed[1] Motor-Boat Meeting Paper

POSSIBLE standardization is a very fascinating phase of the boat-building industry to me; in fact, it is the saving phase of that industry. As has been said, for many years the industry has drifted along because of the lack of standardized products that would create a year 'round market and enable builders to put the business on a manufacturing basis. In the past they practically have been idle for six months and overworked for the remainder of the year. Boats they have built have varied in size and type. Usually, with a dozen craft under construction, a builder would have no two that incorporated the same sizes of lumber. One would expect that two boats under way, each 40 ft. long, 10-ft. beam and 3½-ft. draft, having engines of the same horsepower, the same general arrangement and appearance, would be constructed generally of the same size of scantlings. But one keel may be of 4-in. oak and the other of 4¼-in. yellow pine; one may have ⅞-in. finished planking, while the other design calls for 1-in. planking when finished, the latter requiring 1¼-in. stock and wasting ¼-in. of material. The cabin floor-beams and the cockpit floor-beams may be different. They may be 1⅛ x 2¼ in. and 1¼ x 2⅛ in., whereas both might just as well be 1⅛ x 2 ¼ in. There are two bilge stringers or longitudinals; one may be 1⅛ x 3¾ in. and the other 1 x 3½ in., yet they could both be the same size.

To finish material to a specified thickness is costly to the boat builder and to finish a plank so that it will measure exactly 1 in. thick when the owner or his architect's representative puts a rule on it, requires the use of 1¼-in. stock and throwing away ¼-in. of material. The builder has charged the owner for 1¼-in. stock, but the material is lost and becomes nothing but sawdust. Few boat builders charge for the cost of planing the material. If thicknesses under 1 in. were not permissible, it would be better economy to specify 1¼-in. stock finished to at least a thickness of 1 in. and no one would object if this finishing were to 1⅛ in.

There is great advantage in having all bilge stringers the same size. They can all be run through the planing machine without an adjustment of the machine to provide for various thicknesses; they can be piled together after being milled and one can be picked from the pile with certainty that it is a bilge stringer without measuring the piece before it can be used. Hunting for pieces of certain size and measuring them takes time. This cuts into the boat builders' allowance for labor costs. If the contract is for a fixed price, the builder loses; if it is not for a fixed price, the boat builder passes the cost along to the owner. Standardization, then, benefits the builder, the customer and the boat builders' workmen.

Standardizing means increased production which, in turn, means a lower unit cost and a lower selling price. It means less profit per boat, perhaps, but increased profits on the yearly production. By having a product that can be marketed through the entire year, the boat builder can employ labor to advantage and he and his men know where they stand.

The procedure often repeated in connection with the building of a special boat is that early in the summer the prospective owner has an afternoon trip in his friend's motor boat. He likes it. He begins to get the boat fever. He can afford a boat and vows he will buy one for next summer. The summer passes and he considers buying one then, tempted by quotations on craft for sale at the close of the season. None suits him because he is particular about certain things. During the winter he looks over designs and obtains sketches gratis from various architects who are anxious for orders at that time, and considers. He is further enthused by the display of boats and engines at the motor-boat show. Nothing suits him; the $1,000 launch is too small and the $30,000 cruiser is too far beyond his means. He collects engine catalogs and more sketches, finally gets an approximate idea of the boat he wants and orders its design.

Several others have at this same time decided to go ahead. The architect and his draftsmen work early and late to handle the rush of six months' business in three. The contract is placed. There is competition among busy builders to get the best workmen and some offer inducements to obtain them for a few months of work. The boat builder orders the equipment, the engine and special lumber, and finds that the hardware manufacturers are loaded with unfilled orders. Great delay is experienced in getting materials. If the boat is to be delivered anywhere near on time, much equipment must be substituted for what was specified and usually this substitution is not a gain. Delivery is made in a grand rush. The owner is often forced, owing to the lateness of the season, to accept his boat before it should rightly leave the builders' hands. Consequently, many a trip is spoiled because of something which should have been attended to by the builder and the engine manufacturer before the boat was delivered. There are many cases where the prospective owner decides on his boat, places his order early and gets a perfect craft practically on time, but the condition I have described is ever-present, I am tempted to say that it is the usual condition. It should be corrected and the most satisfactory solution is the standardized motor boat.

Standardized Motor Boats

By standardized motor boats I do not mean standardized cruisers or runabouts of specific dimensions, but a complete line of motor boats of varied standard models and prices. It would then actually be possible for al-

[1] Nyack, N. Y.

most any man to select some craft that would fill his needs, one that he could see and test before he purchased, that would represent a standard value and that could be delivered on time, thoroughly tried out and ready to give uninterrupted service. We are only beginning to reach such a position. If the boat builders of the country produced standard boats of many sizes and types, one could choose a satisfactory craft among them.

Prices range from $200 to $30,000, with very slight price increases between models. Hence a good chance is offered for selecting a standardized boat. To be sure, one can hit in between 36 and 40 ft. and order a 38-ft. model with the galley forward instead of being aft, with an engine of one's own selection that perhaps will give a mile more speed, with built-in berths instead of extension transoms, with greater or less freeboard and a slightly different shape to the bow; but, instead of paying $8,000 for the boat one would pay $12,000. One would have exactly what is wanted, but the test of what one gets is whether it affords equal value in satisfaction and utility. I am not attempting to underrate the services of the men in my profession or the value of the specially designed and specially built boat. Designing boats is my business and that of many others. There is always the designing of special boats and consulting work that one can do. But the future of the small-boat building industry lies in adopting the standardized motor boat and constructing a line of boats for the quantity production of which the boat building plant is best equipped. Firms that do not standardize will find themselves hampered. If they standardize, they may have competition in progressing, but they will progress.

I do not mean that every builder must market a standardized boat built in great quantity. It would be fine if the builder were financed to do that, but boat builders have failed to take advantage of reducing the cost of labor by using quantity-production methods. If manufacturers, contractors and engine builders had followed the practices that boat builders have adhered to for years past, they would have failed in business. Most boat builders are frank to admit that they never made any appreciable profit; which is deplorable. For instance, many an estimate by a boat builder reads: Material $4,000, labor $6,000, profit-and-loss 20 per cent, or $2,000. His material costs are catalog f.o.b. prices; freight, cartage and express costs come out of the profit-and-loss item; his men must unload the lumber and cart it to the yard; they have to spend several days in tuning up the engine. All this comes out of profit-and-loss. The owner naturally insists on insurance until delivery, which may be delayed 30 days; and a further cost is entailed. It is small wonder if, when the boat is completed the record reads: "Loss $2,000." I have seen estimates by owners of respectable-sized boatyards that were made up with no overhead cost considered. The war changed all that. Many owners of boatyards obtained Government contracts. They soon discovered that an allowance of 50 to 70 per cent of the labor cost and 10 per cent of the material cost was necessary on their estimates. The boat builder now knows what "overhead" is; he also realizes that the greater number of times he can turn his capital over during the year, the lower will be his overhead per unit of product.

Summary

The advantages of constructing standardized motor boats are as follows:

(1) A constant market for the product

(2) The boat builder is better able to select workmen, train them, interest them in the work and hold them

(3) Valuable time can be saved during construction

(4) By knowing what his consumption of lumber will be, a boat manufacturer can buy in exact quantities without too great an excess for leeway

(5) The builder can buy materials at the most advantageous time, and does not need to buy them when others are clamoring for material

(6) The firm's books need not show thousands of dollars tied up in material and equipment that lie in the yard deteriorating, while waiting for possible future use. Many a builder could operate his yard an entire winter on the money thus invested

(7) The firm can reduce the deterioration of the plant by continuous operation. A building or a machine deteriorates much less when it is in use

(8) By having boats going through the shops continuously, the builder gives the impression of efficiency and being busy. Customers like to deal with the busy man; they avoid the store with no one at the counters and flock to the one having a crowd of purchasers

(9) By turning out a standard boat that is widely distributed and used, the builder soon knows if his product does not stand up in service and, by using equipment under identical conditions, he is able to remedy defects

In regard to the time that can be saved during construction, consider the actual hours lost by workmen in going back and forth to the stockroom for tools. The best men unconsciously waste hours in sorting over boards, counting out nails or screws and carrying galvanized rod to and from the blacksmith shop and the job. With standardized production the construction is carried along in stages. After the most satisfactory design is gotten out and the patterns and templets are made for all parts of the boat, when the first master boat is ready, one gang does nothing but select and mark lumber, and another gang mills it. The construction gang fabricates; each group does a certain part of the work. One group sets up the forms and the main frame, another bends the frames, a third installs the planking, and a fourth finishes and erects the joiner work. From the master boat a pattern of every part is made, and the parts themselves are built and stored near to the hulls. Bins should be installed close by each hull and kept supplied with sufficient quantities of proper-sized bolts, nails, screws and the like. The engine installation should be made at some given location in the shop. The boats should be shifted on a track, or an overhead traveling crane should serve the whole shop. All parts necessary for an installation should be kept near the job. In such ways time can be saved.

So far as I know, S.A.E. Standards are in use on all standard-sized motor boats; they should be, especially for such features as the taper of propeller-shafts. If the engine builders could unite upon standard dimensions for bed-plates, angles, the sizes of holes and the like, the movement would be much assisted. By manufacturing a nationally advertised product, the boat builder can obtain reputation and prestige that he would gain in no other way. He learns advertising, selling and shipping. He comes into contact with people and this broadens him. The whole idea of standardized motor boats offers advantages to all concerned.

A Suggested Rating Rule for Racing Cars

By H. M. Crane[1]

Annual Meeting Paper

IN recent years automobile engines have been very generally rated for racing purposes in accordance with their piston displacement. The rule in most general use last year placed a limit of 183 cu. in. on this feature. The natural result of this method of rating has been to encourage the highest possible engine speeds with the object of obtaining the greatest possible piston displacement per minute. There is plainly no limit to the power that can be attained in this way, except that imposed by the great loss in mechanical efficiency at very high speeds and the increasing difficulty of maintaining a reasonable volumetric efficiency at such speeds. Much has been learned regarding the design of high-speed engines from the work done under this rating rule, but I think the time has come when we can expect to get very little more of value from a continuance of it for purposes of the commercial design of passenger cars and trucks.

Most automotive engineers are familiar with the features of engine design that have been developed under this rule. We find enormous valve areas, usually obtained by a multiplicity of valves; huge inlet pipes and carbureters, extreme valve-timing and very light reciprocating parts. However desirable these features may be for racing purposes, all experience indicates that they are highly undesirable in commercial engines. Those first mentioned make good performance at moderate and low engine speeds absolutely impossible with the present type of fuel, while the very light pistons used cannot be expected to give either reasonable wear or proper control of lubrication in commercial service.

I doubt whether it would be possible to formulate any rating rule that would tend to develop a really commercial type of engine for racing purposes, but I believe that it should be possible to do something to encourage engines of a type developing higher efficiency at lower speeds than is now the case. My suggestion is the development of a rule under which cars will be rated in accordance with the piston displacement per mile actually used by them. Such a rule would involve rear-wheel diameter and gear ratio, as well as the piston displacement of the engine. This would automatically allow the use of engines of varying size provided the other elements were properly proportioned. The use of gearboxes in most racing cars would perhaps make the application of such a rule difficult if not impossible in the case of road races in hilly country. In the case of track races or races on the flat, such a rule should be readily enforceable.

I am bringing forward this suggestion in the hope that it will induce automotive engineers to think along these lines. Racing is very expensive and I think the matter of getting more information of real engineering value out of it, if possible, is worthy of the most serious consideration.

[1] M.S.A.E.—Consulting Engineer, New York City.

RECORD GASOLINE PRODUCTION

THE production of gasoline in September set another new high point, the total production being 453,881,096 gal., or a daily average of 15,129,370 gal. This daily rate represents an increase of approximately 5½ per cent over the preceding month when the daily production was 14,327,143 gal. The daily average for September, 1919, was 11,319,419 gal., and for September, 1918, 10,486,532 gal. The average production for September of this year represents an increase of approximately 44½ per cent over the daily rate of 1918.

The stocks on hand at the refineries on Sept. 30, 1920, amounted to 288,195,394 gal., as compared with 371,125,419 gal. on the corresponding date of last year, a decrease of approximately 22 per cent. Compared with 1918 when the supply of gasoline on hand at the refineries amounted to 269,772,723 gal., the refineries had in their tanks approximately 10.7 per cent more gasoline than two years ago. At that time the stocks were being rapidly depleted, the lowest point being on Oct. 31 of that year.

Large as the September production was the figures for October surpassed it, the production for that month being 465,787,745 gal. This is at the daily rate of 15,025,411 gal., as compared with 11,724,411 gal. for the corresponding month of 1919, and 10,137,139 gal. for 1918, or approximately a 50 per cent increase in two years.

On Oct. 31, 1920, the gasoline in storage at the refineries was 301,283,731 gal., as compared with 288,195,394 gal. on Sept. 30, 1920. This indicates that the usual low point in gasoline stocks which occurs each fall has been reached and that during the succeeding winter months when climatic conditions curtail the use of gasoline consuming vehicles the refineries will have a chance to replenish their stocks. In both 1918 and 1919 the low point in the quantity of gasoline in storage at the refineries was reached on Oct. 31, the figures for these years being 250,328,329 and 354,160,071 gal. respectively. In 1917 the low point was reached on Sept. 30, the same as in 1920.

COMMERCIAL REACTION

WE are experiencing the natural sharp reaction from an unnatural period during which the elements entering into the making of prices were overplayed and tendencies indulged which upset the normal movement of commerce. There has been no weakening in the fundamental soundness of the nation's economic position. Credit resources are sufficient for legitimate commercial needs, even if commodity movements were in normal volume.—J. H. Tregoe.

WATER POWER

ACCORDING to the report of a French investigating committee the United States is rated as having 30,000,000 hp. in water power, Canada 25,000,000, Norway 7,500,000, Sweden 6,750,000, Austro-Hungary district 6,450,000, Italy and Spain about 5,500,000 each. Germany's water power is estimated at only 1,500,000 hp., and that of England is about 1,000,000 hp., but these two countries are richly compensated in coal.—*Power.*

Air-Temperature Regulation Effects on Fuel Economy

By Reuben E. Fielder[1]

Annual Meeting Paper *Illustrated with* Charts and Drawing

TWO serious problems confront the automotive industry in connection with the present fuel shortage. First, there is the problem of securing a much higher degree of economy with existing equipment; then, apart from this, there is the matter of future design. These problems are of nearly equal importance, since existing equipment will undoubtedly be in operation for a number of years to come; yet nearly all of the authorities on the fuel question are confining themselves to the future. As we see the situation, it is highly desirable that some attention be paid to the problem immediately facing us.

The steadily increasing cost of gasoline is a particularly serious matter for the Fifth Avenue Coach Co. The price paid today is practically four times what it was when we began to operate, although our rate of fare remains the same. We use several million gallons of gasoline each year; our fuel bill constitutes our second greatest item of expense. For this and many other reasons, we are constantly experimenting with devices of various kinds to improve fuel economy. Of the different devices that we have tested, our thermostatic temperature control for the carbureter appears to afford greater possibilities of saving than anything else that has been brought to our attention.

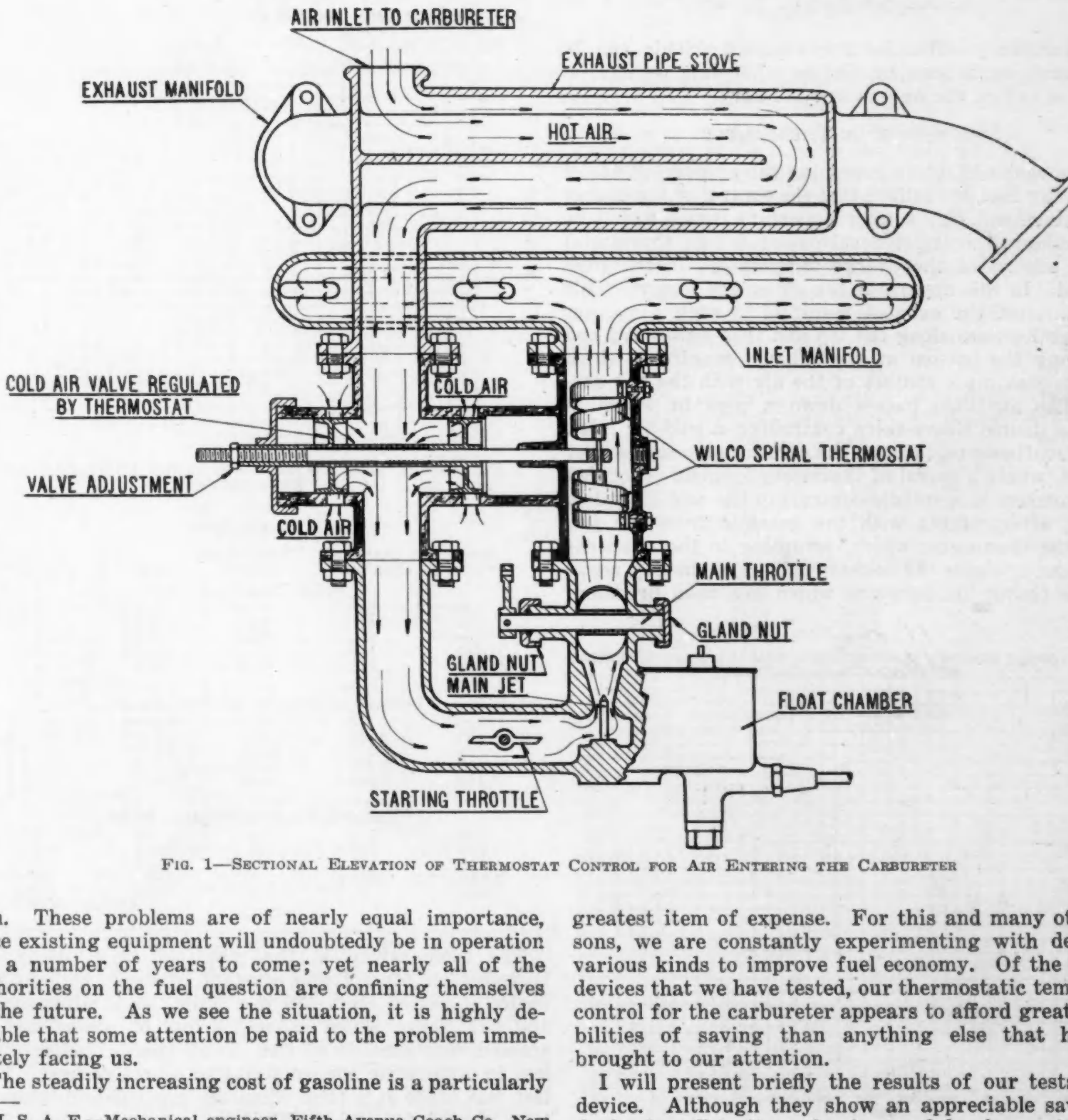


Fig. 1—Sectional Elevation of Thermostat Control for Air Entering the Carbureter

I will present briefly the results of our tests of this device. Although they show an appreciable saving, the device is still in its early stages of development and pre-

[1] M. S. A. E.—Mechanical engineer, Fifth Avenue Coach Co., New York City.

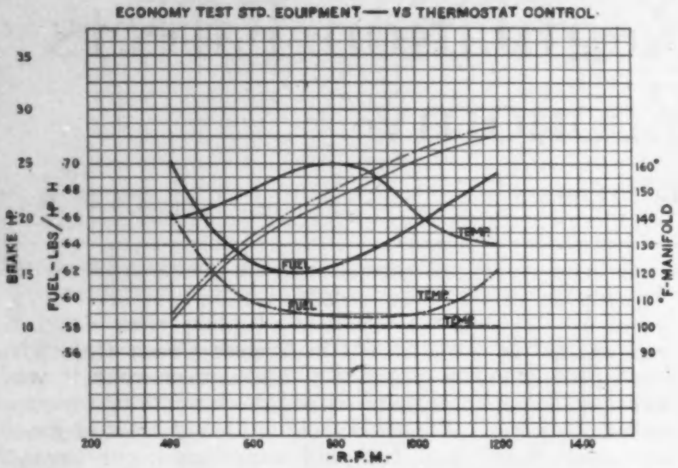


FIG. 2—RESULTS OF ECONOMY TEST SHOWING SAVING IN FUEL CONSUMPTION AND INCREASE IN HORSEPOWER OBTAINED AS A RESULT OF USING THE THERMOSTATIC CONTROL

sents further possibilities for research. This can be accelerated, we believe, by placing what data we have at this time before the automotive industry.

DESCRIPTION OF THERMOSTAT

Of the various factors governing the economical use of present-day fuel, we believe that the control of the charge temperature will play a most important part. Fig. 1 on page 1 shows the latest development of the thermostat for the control of the charge temperature in the inlet manifold. In this apparatus the air enters a stove. This is cast around the exhaust manifold in such a manner that the air passes along the top and then downward and back along the bottom of the exhaust manifold, which gives the maximum contact of the air with the hot surface. The air then passes down a pipe in which is located a double sleeve-valve controlling a cold-air inlet. The air continues on through the carbureter into the inlet manifold, where a spiral of thermostatic metal is located which connects to a spindle controlling the cold-air valve. The air, after mixing with the gasoline from the jet, strikes the thermostat which, according to the temperature, opens or closes the cold-air valve and thereby regulates the charge temperature which has been predetermined to suit the grade of gasoline being used. The temperature in the inlet manifold can be varied by adjusting the relation of the cold-air valve with its inlet ports. Air leaks are a source of trouble and it is necessary that all joint gaskets be tight. We have found also that it is advantageous to use packing glands around the throttle spindle.

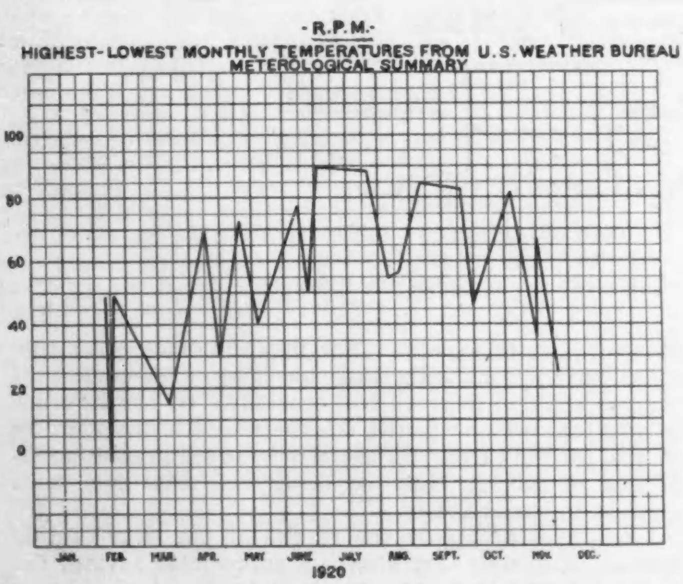


FIG. 3—MAXIMUM AND MINIMUM MONTHLY TEMPERATURES AT NEW YORK CITY FOR THE YEAR 1920

COMPARATIVE TESTS

Comparative tests have been made with and without this thermostatic-control device, using the same engine, carbureter and similar equipment, under the same atmospheric temperature conditions. The results are shown in Fig. 2, where the average saving in fuel consumption is 7.85 per cent and a 5 per cent increase in horsepower was obtained when using the thermostatic control. We have obtained a greater saving than this in other tests, but the figures given can be considered most conservative. Table 1 shows comparisons taken from Fig. 2.

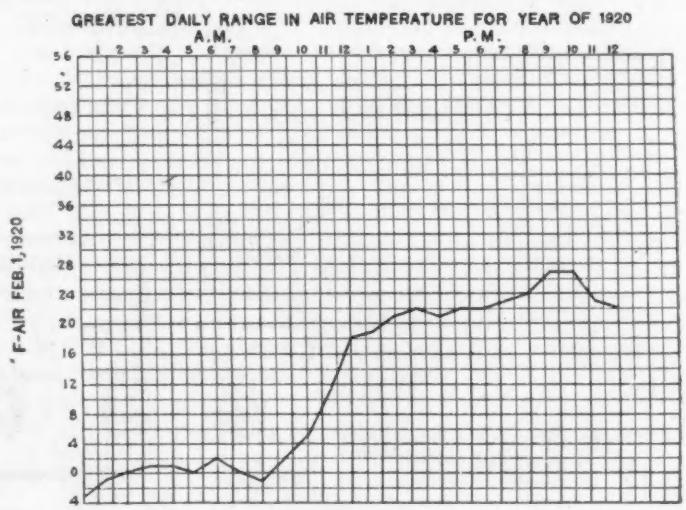


FIG. 4—A TYPICAL CHART SHOWING THE DAILY RANGE IN TEMPERATURE

TABLE 1—ECONOMY TEST

Speed, r.p.m.	Standard Equipment	Thermostatic Control	Difference	Difference, Per Cent
		Power Developed, Hp.		
400	10.5	11.2	+0.7	+6.6
600	17.7	18.0	+0.3	+1.7
800	21.5	22.5	+1.0	+4.6
1,000	25.3	26.3	+1.0	+3.9
1,200	27.6	28.2	+0.6	+2.2
			Average	+3.6
		Fuel Consumed, Lb. Per Hp-Hr.		
400	0.702	0.664	—0.038	+ 5.4
600	0.628	0.598	—0.030	+ 4.8
800	0.626	0.588	—0.038	+ 6.1
1,000	0.655	0.590	—0.065	+ 9.9
1,200	0.694	0.622	—0.072	+10.3
			Average	+ 7.3
		Manifold Temperature, Deg. Fahr.		
400	139	101	—38	—27.2
600	150	101	—49	—32.6
800	159	101	—58	—36.5
1,000	144	101	—43	—29.8
1,200	131	101	—30	—23.0
			Average	—29.8

The temperature in the manifold when using the thermostatic control was constant, whereas without this device it varied from 130 deg. fahr., as a minimum, to 160 deg. fahr., which showed a loss of power and increased consumption of fuel at all speeds, indicating a loss in volumetric efficiency due to excessive heat. This test was made at a time when the atmospheric temperature was 68 deg. fahr. What happens when the atmospheric temperature is around 90 deg. fahr. as in the

summer, or 0 deg. fahr. as in winter, can well be imagined.

Temperature Variation

Fig. 3 shows the highest and lowest temperatures by months for 1920, taken from the New York City station reports of the United States Weather Bureau. It will be noted that the temperature in February is 4 deg. below zero fahr.; yet in the same month it reaches 48 deg. above zero fahr., which is a range of 52 deg. fahr. In July the temperature reaches 90 deg. fahr. This is a considerable degree of heat, but there are many other things which make it worse; for instance, in summer we have the radiation from the pavements and the hot air coming from the radiator to contend with, and in winter bleak winds are encountered. In addition, we have a considerable temperature range within even a few hours, as is shown in Fig. 4, which is taken from the weather report for Feb. 1, 1920. At midnight, it is 4 deg. below zero fahr. and continues below zero until 8.00 a. m. Then it rises 20 deg. in the next 4 hr. and at 9.00 p. m. it is 27 deg. above zero fahr. This is a total range of 31 deg. for the day, which is by no means an exception.

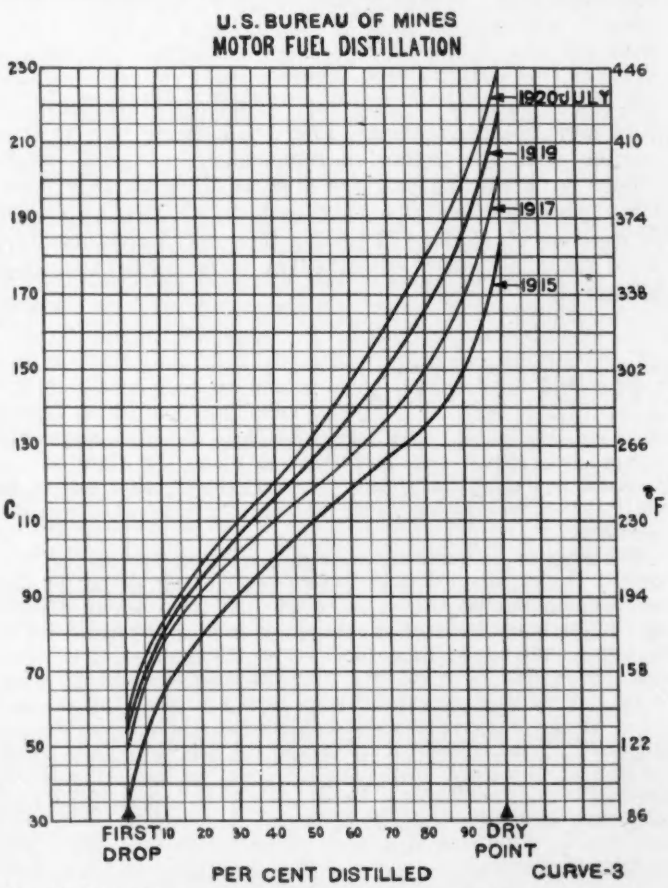


Fig. 5—Fuel Distillation Curve Showing the Variation in the Volatility of Gasoline Between 1915 and 1920

Fuel

The volatility of gasoline has changed considerably since 1915 as is shown in Fig. 5. This is a fuel-distillation curve supplied by the United States Bureau of Mines and the comparisons are shown in Table 2.

TABLE 2—COMPARATIVE FUEL DISTILLATION CURVES

Year	First Drop, deg. fahr.	Amount Distilled at 212 Deg. Fahr., per cent	Dry Point, deg. fahr.
1915	95	40	360
1920	133	22	446

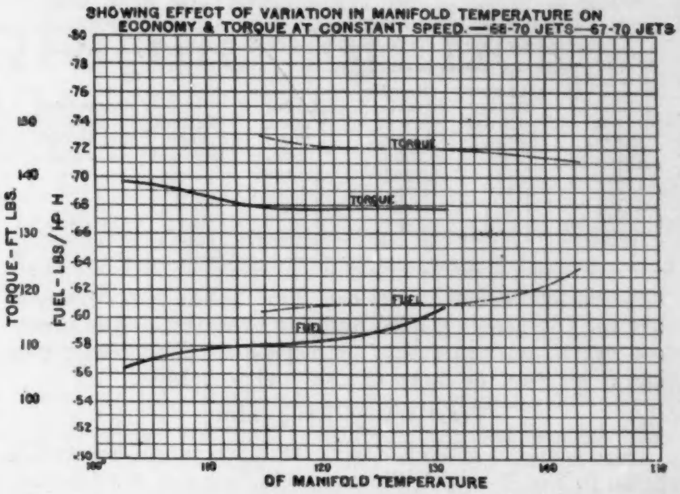


Fig. 6—The Effect of Variation in Manifold Temperature on Fuel Economy and Torque Developed

Desired Manifold Temperature

The thermostat is set to control the manifold temperature at about 102 deg. fahr. This temperature was determined upon after tests in which the engine speed was held constant while varying the temperature in the manifold, the power developed and the fuel consumption being recorded. The speeds selected were 700 and 1200 r.p.m., thus representing the high and low range of speed.

Fig. 6 shows two tests at 1000 r.p.m. with 68-70 and 67-70 jets. The No. 70 jets were used only for starting and idling speeds. The comparison with a No. 68 jet, shown in Table 3, is interesting and indicates a loss in volumetric efficiency due to the expansion of the air at high temperature.

TABLE 3—EFFECT OF VARIATION OF MANIFOLD TEMPERATURE ON ECONOMY AND TORQUE, WITH DIFFERENT JETS

Temperature, Deg. Fahr.	Jets 68-70	Jets 67-70	Difference	Difference, Per Cent
		Fuel Consumed, Lb. Per Hp-Hr.		
115	0.581	0.605	+0.024	—4.1
120	0.585	0.609	+0.024	—4.1
125	0.591	0.610	+0.019	—3.2
130	0.605	0.611	+0.006	—0.9
			Average	—3.1
		Torque, Lb-Ft.		
105	138.5	.....	......	.....
110	136.0	.....	......	.....
115	134.5	147.0	—12.5	+9.3
120	134.0	145.5	—11.5	+8.6
125	134.0	145.0	—11.0	+8.2
130	134.0	145.0	—11.0	+8.2
			Average	+8.7

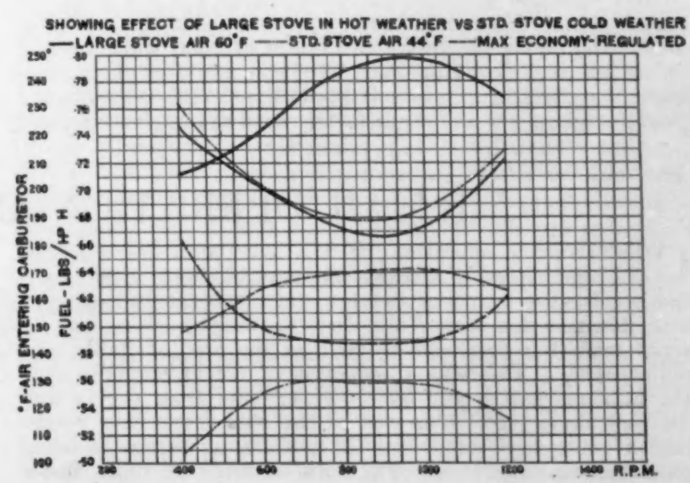


Fig. 7—Effect Upon the Quantity of Fuel Consumed per Horsepower Hour with a Large Stove in Hot Weather Compared with That of a Small Stove in Cold Weather

TABLE 4—EFFECT UPON THE QUANTITY OF FUEL CONSUMED PER HORSEPOWER-HOUR OF A LARGE STOVE IN HOT WEATHER COMPARED WITH THAT OF A SMALL STOVE IN COLD WEATHER

Speed, r.p.m.	Large Stove, Air at 68 deg. fahr.	Small Stove, Air at 44 deg. fahr.	Difference, deg. fahr.	Difference, per cent	Combined Fuel Economy, per cent
400	0.748	0.764	+0.016	—2.1	0.756
600	0.701	0.704	+0.003	—0.4	0.703
800	0.671	0.680	+0.009	—1.3	0.675
1,000	0.674	0.687	+0.013	—1.9	0.680
1,200	0.722	0.730	+0.008	—1.1	0.726

Indications are that 102 deg. fahr. is the best temperature for the gasoline used and our thermostat was therefore set to maintain this temperature. The result was that 8 per cent or more of the fuel was saved.

Volumetric Efficiency

The necessity of considering this important matter is shown in Fig. 7, which illustrates the gain of the thermostatically controlled equipment over the standard equipment. Much of this gain is due to an increase in volumetric efficiency with the cooler air. For example, at 800 r.p.m., we have with the standard equipment a charge temperature of 160 deg. and with thermostatically controlled equipment 102 deg. fahr. This is a difference of 58 deg. fahr. An approximation of the amount of expansion for 58 deg. fahr. is 12 per cent. This means that there is 12 per cent less oxygen entering with the charge under standard conditions. Assuming that the same vacuum exists at the same speed, it will be seen readily how the temperature change from day to day affects the mixture quality.

TABLE 5—SAVING IN POUNDS OF FUEL CONSUMED PER HORSEPOWER-HOUR OVER COMBINED MAXIMUM AND MINIMUM ECONOMIES PRODUCED BY THERMOSTATIC REGULATION

Speed, r.p.m.	Combined Fuel Economy	Thermostatic Regulation	Difference	Difference, per cent
400	0.756	0.664	—0.092	+12.1
600	0.703	0.598	—0.105	+14.9
800	0.675	0.588	—0.087	+12.9
1,000	0.680	0.590	—0.090	+13.2
1,200	0.726	0.622	—0.104	+14.3
			Average	+13.5

Table 4 shows that the proper temperature to insure the greatest economy is not entirely controlled by volumetric efficiency. The effect of too much cold or hot air on economy, as compared with the thermostatic control, clearly shows the necessity of finding the correct temperature. Table 5 shows the saving over combined maximum and minimum economies produced by thermostatic regulation.

Conclusion

This paper is presented with the idea primarily of bringing out constructive criticism. We believe that the principle of thermostatic temperature control is correct, but its detailed application is still a matter for further experiment. That there are certain periods during the year when the average internal-combustion engine functions with the minimum amount of trouble is scarcely open to argument. This is due to the fact that at that time the atmospheric temperature is right. Our idea is to select this period and to standardize it for use throughout the remainder of the year. This certainly seems to be a logical arrangement. There is nothing new in connection with the theory of temperature control. Many others have worked and are still working on this problem. Among those who have cooperated with us I wish to mention E. R. Hewitt of the International Motor Co., who has done much constructive work along the lines indicated.

SUPERPOWER SURVEY

CONGRESS at its last session placed upon the Department of the Interior the duty of making a special investigation of the possible economy in fuel, labor and material that could be secured by the electrification of the railroads and industries of the region between Boston and Washington. The plan contemplated is a unified system of power generation and distribution, and its investigation has been called the superpower survey. This is now under way. The engineering profession and large business interests are giving this project support that is at once an indorsement and a promise of public confidence. The engineering staff engaged in this intensive study of the power needs and the means of meeting that demand includes men who have done pioneer work in applying electricity to the use of man; while serving on an advisory board are men of vision and experience, representing our larger railroads as well as electric railways, our manufacturing and mining industries and the engineering and chemical profession, busy men who have accepted an invitation to help direct this investigation along the lines of the greatest practical usefulness. Every industry that has to do with either making or using power is giving generous cooperation.

The area being studied, while only a small fraction of the United States, uses 24 per cent of the electric output of the central stations of the country and produces about 47 per cent of its manufactured products. It is properly termed the finishing shop of American industry. The report of this investigation will be completed June 30 next, and its purpose is to give an engineering solution to the problem of the demand of the Nation for greater production and better transportation. That answer is electrification, but its details must include an accurate statement of costs in capital and of savings in coal and labor.—From the recent annual report of Secretary of the Interior, J. B. Payne.

AIR MAIL OPERATION AND MAINTENANCE COST

CONTINUED operation of the Air Mail Service has brought about a marked decrease in the cost per mile flown. For the month of October, 1920, the average cost per mile flown on the New York City-Washington route was 78 cents including overhead as well as the cost of flying and maintenance. This was a reduction of 1 cent per mile over the previous month and 80 cents per mile from the figures for February, 1920. The cost of the New York City-Washington route in October was $14,985.20, as compared with $14,229.69 in February. The total number of miles flown increased from 9029 in February to 19,242 in October. The cost per mile flown for the entire service was 80 cents. This is due in part to high overhead and maintenance costs on the Salt Lake City-San Francisco route, the maintenance cost per mile alone being 74 cents.

In the month of October seven routes were in operation between New York City and Washington, St. Louis and Twin Cities, New York City and Cleveland, Cleveland and Chicago, Chicago and Omaha, Omaha and Salt Lake City, and Salt Lake City and San Francisco. The total cost of the Air Mail Service for the month was $123,618.68. The total number of miles flown was 154,486.

Style in Automobile Bodies

By George J. Mercer[1]

Annual Meeting Paper *Illustrated with* Drawing

It is not difficult to forecast the immediate future of the trend in automobile body models for large business or quantity production. Special designs vary according to the individual taste of each customer, but quantity business necessitates a design that will please the majority. The design must be a compromise between the old and the new. Its mission is not so much to excite comment as to placate users, because builders doing a universal business are bound to standard practice. I think that builders who produce what is termed a standard body model are not always satisfied with the appearance of their cars. On the contrary, I believe that the majority feel at times the urge to break away from stereotyped lines and produce something more distinctive but, if the volume of business is satisfactory, the most that such an effort will accomplish is some general refinement.

The design of an automobile body is one of the best advertising features of the car. The appearance alone often will make or mar a car sale. The body not only counts for appearance but, within its scope, it controls the comfort and much of the pleasure of motoring, and to some degree it insures the safety of the passengers. The potential benefits of an attractive body design as a sales booster are well understood; frequently the substitution of snappy uptodate body models will revive the selling force and add new life to the entire manufacturing organization. Provided the mechanical features of the car are sensible and correct, such changes are all that is required to produce a larger business.

Fortunately, several factors contribute and converge to make body changes practicable. For example, regarding the proportionate cost, in the case of an open car selling for $1,200 to $1,600, the body, including the top, windshield, mudguards and the like, costs about $400, or approximately one-third of the total cost. It is, therefore, not an expensive unit. The manufacturing outlay to produce an automobile body is at a minimum compared with the fixtures and tooling-up that are necessary to manufacture the mechanical units; in addition, the body is always made individually by each manufacturer, but the mechanical parts are most often commercial articles. For such reasons there is a certain flexibility about the body unit and, adding to this the greater apparent value for the money spent, changes in body styles are made practicable whenever the necessity arises.

The number of different body models that will prevail during the coming season is less than in past years. For example, a few seasons ago one manufacturer listed 14 body styles that were in regular production. The greatest number of models listed by one manufacturer during the past year was eight; the majority listed four and this latter number probably will be the number of different models made by most manufacturers in the coming period or, if the touring car is considered, in two divisions, a total of five styles.

Prevailing Body Types

The models that will prevail during the coming year are the five-passenger touring car, the two-passenger runabout, the five-passenger sedan and the four-passenger coupe. The seven-passenger touring car and the seven-passenger sedan will be made in limited numbers; at times the latter will be built with a division, thus making it a two-compartment car. The touring body, that has remained stationary for so long as regards development, is surely developing into two divisions to meet existing needs.

The sport-type touring body is usually a four-passenger design; it is intended to appeal to the younger element who want low racy lines that indicate speed. This type of body is generally painted in loud colors and is a compromise between the sport runabout and the touring body of conventional type; it has the same seating capacity as the latter and some of the smartness of the former. This sport model is an offshoot from the standard touring-body design, but manufacturers making both give them distinctive names and list them as individual models. However, the greater volume of business is still with the larger or five-passenger body. Although the sport model appeals to the minority, it is a very important factor. Its mission has already been shown in clarifying the runabout proposition.

There have always been runabout users who wanted a small body with seat room for more than the normal passenger capacity. The runabout logically has a two passenger body and when so made there is a certain definiteness in its design. The desire for more seat room brought out combination models in the past that have been short-lived, but those who require seat room for three or four passengers are best served by a close-coupled miniature-type four-door touring body. The runabout will hold its place as a necessary model, but it has been decreasing in numbers during the past two years. The five-passenger body seems to have been a satisfactory substitute for both the larger and the smaller body types. The runabout as made by the different manufacturers today is more uniform than formerly and has fewer freakish characteristics. When equipped with the all-seasons top, it is a sensible car for doctors and professional men.

The five-passenger sedan with four doors has undergone but one change within the past year. This has been the substitution of the straight for the slanting front, which simplifies manufacture and is more practical for small cars. The four-door sedan as we have it today comes nearer to meeting with universal approval than any body design that has ever been introduced. It has superseded all other forms of closed body for general use except the coupe, which finds favor because it is a minia-

[1] M.S.A.E.—Consulting body engineer, Saxon Motor Car Co., Detroit.

ture of the four-door sedan. The sedan has been simplified in construction by using belt molding that runs all the way around, and the same condition exists at the drip. These two moldings eliminate the welding of the panel. The drip molding covers the top material edge effectively or at least permits the use of a small corner molding under which the top cloth is finished, without its being evident.

The soft roof is used extensively. This roof is formed of waterproof material drawn over padded wooden strips and has been one means of keeping costs down during the period of high prices. Another feature on present-day closed bodies that differs from former practice is that the belt line is higher. Formerly, the window of the side was made as long as could be dropped flush in the door; today this line is carried at least 2 in. higher. The result is that the body looks lower and the quarter window light does not project so high above the body line when it is lowered.

The modern sedan has a four-door body and five-passenger capacity. It has a moderately square appearance. The lines are severe, with from 1 to 3-in. radius at the rear. The roof is moderately thin and has a straight molding line. Moldings are used on the doors. On the sedan moldings are used more than on any other body. This is done principally to give it a straight-line square effect and for economy in manufacture. On high-priced and specially designed bodies the use of molding is less conspicuous.

The favorite coupe has a four-passenger body. This body has had periods of oscillation between the two, three and four-passenger sizes, but has finally settled to the four-passenger size for quantity production. The smaller sizes of coupe have found favor with doctors and professional men but, for the majority of users the coupe is used and is expected to do duty in place of the miniature sedan. It has the compactness that makes it suitable for shopping and business and, as the fourth seat is of the disappearing type, a comfortable entrance is provided to any seat; in addition, accessible carrying space both inside and at the rear of the body is provided.

The bodies that have been enumerated are the most representative. They comprise the total of the models that builders of medium-price cars will list and market, because they meet adequately the requirements of the average buyer. Individual features naturally will be added to a limited extent, for their advertising value. Some will use the square rear corner; if it is used it is best adapted to the coupe and should be without molding.

The lack of a cheap closed car brought forward winter tops for open bodies. To some extent these met the needs of service, but their appearance was disappointing and they have all been superseded by the California top. This top fills service needs and adds to the general appearance of the car. When it becomes generally used and is in production, the price will fall and the open car so equipped will not cost as much as a coupe, although the cost is approximately the same at present.

A body with a well made California top is the ideal all-season car for the majority of users. The top is light and will therefore not rack itself to pieces. A top made with supports only at the back and front will deteriorate in this way, if lightness and flexibility are lacking in the construction. The cold and the warm seasons are sensibly provided for by fitting the panels with glass for winter, removing and replacing it with curtains for emergency use during warm weather. Manufacturers are recognizing the value of the California top and it constitutes regular equipment on both touring and runabout bodies with some builders.

Body Lines

The body lines that will prevail during a coming season are variable in their method of development. Specially built cars are the trial horses for developing new body lines. A very important factor and one that has an important influence on quantity production is the misuse of the prevailing style in body lines. This brings about a reaction toward more or less of a resumption of body lines that preceded the prevailing style.

The straight line with angular corners is giving way to moderately rounded surfaces, but the straight effect is simulated. The movement is not reactionary; it is illustrated in Fig. 1, which shows the forward end of the car and the body as far back as the windshield line. The purpose of Fig. 1 is to show how, with rounded surfaces on the radiator, engine hood and body shroud, the effect is straight through from the body top line. Three points, *A*, *B* and *C*, have been taken for illustration; the cross-sectional development is shown at *A-1*, *B-1* and *C-1*. The center of the radii of these three points is projected to the vertical plane to intersect with the lines *A*, *B* and *C*, and through these intersections a line *E* is drawn. The line *E* is parallel with the line *D*, which is a theoretical line that represents the top of the body side continued to the front. The point is that the metal forming the radiator, hood and shroud has its bending point on the line *E*. The line *E* can be slightly above or below the line *D* but, if it is reasonably near, when the front is painted and shows the light and shadow, it will appear as if the line *D* was continued right through to the radiator. It is not presumed that it will be sharp, as would be the case if the metal had a corner, but the appearance to the eye is harmonious.

An additional advantage is that the same hood must be used in production for open and for closed models. With a corner in the metal it is not easy to adapt it to the closed body; also, the height of the body sides will vary on different open bodies, so that the adoption of the plan illustrated in Fig. 1 simplifies the designing and has a beneficial effect on the manufacturing costs. The radius used on the corner is not arbitrary. The effect is most pronounced with a radius of about 1½ to 2 in., starting at the radiator. But almost any radius is permissible, always provided that the turning line of the metal is parallel to the theoretical line *D*. Coincident with the hood and radiator as shown, the flat top edge with a slight radius to the outer edge has superseded the bevel edge. The back corner of the body will be round, with a radius of from 4 to 6 in.; the sides will be of the moderate height of 22 or 23 in. and the back will be high, for comfort when using the rear seat.

Minor and General Considerations

Other features that have come into use and that increase the commonsense usefulness of the open body are the more general adoption of both inside and outside door handles; the use of rear top rest-irons that are taken off when not required; a superior quality of springs in the seat cushions, even in moderate-priced cars; higher hoods and radiators that give the appearance of vigorous motive power and, by their comparison in height with the body side, help to make it look lower. There seems to be a general tendency to use cowl lamps. The use of the sun visor has not been as general as it promised to be at one time.

The quarter window on both closed models has been made of less than conventional size and irregular in shape; we can expect those builders who have experienced success with it to continue to use it. The ventilator on top of the shroud is not needed, because the lower part of the windshield is movable and provides ventilation. All closed cars are made with large rear window for observation and in connection with it the mirror for the driver has real value. There is need of a better method of signalling than to have the driver wave his arm at the side. Touring cars are sometimes provided with a slit for this latter purpose in the side curtain when the top is up; again it is necessary to leave one curtain off. The signal should be automatic, operated by the clutch or brake, and should show a light also.

The value of having the design of the mudguards, radiator, hood, lamps, painting and trimming in harmony with the body design is fairly well understood; in fact, these features are the most conspicuous in distinguishing the different cars. The mudguards on most cars today are suited for their purpose and sensible. The crown guard with special formed edges is always an evidence of expensive toolwork. The front guard looks best when made long. The rear guard is at its best when it follows the contour of the wheel well down and is just below the wheel center. The width should never be less than 10 in. and an 11-in. width is better when used with running boards.

Radiators must be high and at least 24 in. above the frame, to permit a high hood and shroud. They look best when $1\frac{1}{2}$ in. narrower at the top than at the bottom and there is a growing tendency to have them nickel-plated. The hoods will continue for some time to have long narrow louvres. The demand for as much enameling as possible, which includes at least the enameling of the hoods, mudguards and splashers, controls the painting combinations. The use of dark colors, without striping, prevails. The lamps also are enameled, being relieved with either a nickel rim or band. The greater durability of enamel as compared with painted surfaces, is one of the urges toward all-metal bodies, but changes in design and the initial high cost will cause the manufacture of the wood frame, the aluminum and the steel panels to continue for some time. Metal panels for the whole exterior except the roof are the standard. At times we have had closed bodies, generally coupes, with the upper panel made of imitation leather but commercially the metal panel has eliminated all competitors.

The trimming design on both open and closed bodies has remained the same for some time. The straight or French pleat continues to deserve favor. On open bodies leather for the seat and back coverings and imitation-leather coverings for the flats and back of the front seat have been the nearest to economy that real service would permit. The use of robe rails is usual, but the foot-rest is used intermittently. The general plan for all bodies is simplicity. Even the closed bodies have less ornamentation than formerly and the omission of toilet or vanity cases and flower holders is common. One dome light and, at times, corner reading lamps, constitute the sole appointments, except that the instrument-board may include a clock in addition to the usual necessary equipment, making this board the repository of practically all of the appointments.

The use of the window lifter is general for the doors of all closed bodies. The ornamentation on the silvered interior parts is in better taste and harmony than formerly and the material for the trimming is more frequently selected for its durability than for show. Cur-

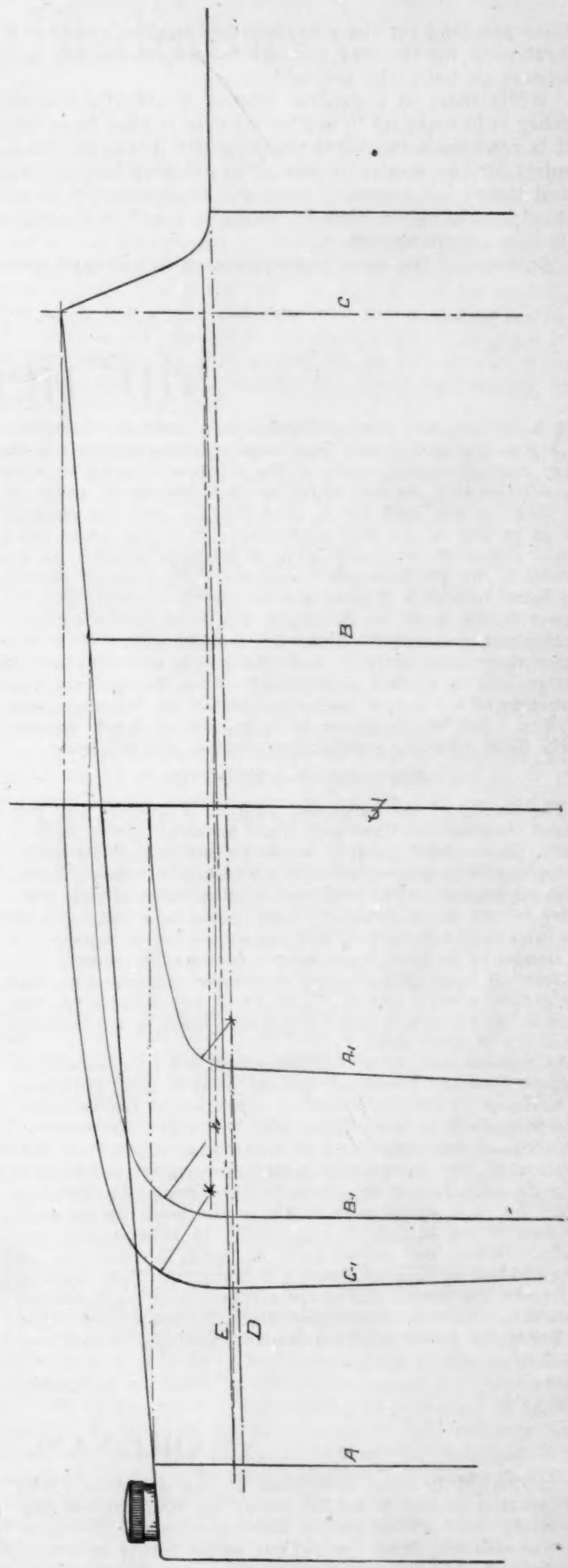


FIG. 1

tains are used for the rear, side and back windows only. Arm rests for the rear seat are in general use, but armholders or hat-racks are seldom seen.

While there is a general tone of simplicity, the tendency is to make up in quality what is lacking in variety. It is reasonable to believe that this will be the prevailing spirit for the season to come. The automobile body is so well known, so generally used and so thoroughly understood by the public, that its intrinsic worth is becoming its best advertisement.

Builders of the more expensive cars will always make their product of an approximately special-to-order class. Purchasers who are able to buy without counting the cost insist on body designs that are uncommon. Those who produce cars in large numbers for this class of trade usually follow a design that is not extreme, and that relies for its attractiveness upon the fine quality of the workmanship and the high quality of the material used. The chauffeur-driven car is the rule. The limousine and two-compartment sedan will prevail, with the town limousine, the town brougham and the cabriolet as the types having the lighter bodies.

THE HELICOPTER

As an invention the helicopter is in embryo. For those who regret that they were unable to take any part in the very earliest developments of the airplane it may be some consolation to know that so far as the helicopter is concerned, if there is any field for it, that field is open for anybody to go in and do the real pioneering. It is not many years since engineers generally gave a negative answer to the question, "Is the helicopter possible?" They would express no belief in such a type of aircraft on the grounds that the power which could be developed would be barely sufficient to support the weight of the powerplant only. With time those views have changed, and advances in thermodynamical design and in applied aerodynamics have brought the construction of a practical helicopter within the bounds of possibility. But big problems have still to be faced, particularly those affecting stabilization, control and efficiency.

Airplane vs. Helicopter

The ability of the helicopter when in a more or less perfected state to rise from and alight on small spaces such as roofs, squares and gardens would be useful, and its ability to hover at any desired point in the atmosphere may possibly have advantages. The problem of alighting or rising when there is any wind, however slight, must be a very difficult one, and engineers believe that for some time to come it will be necessary to have large spaces such as the present airdromes. A large twin-engined commercial airplane can clear the ground after a run of 300 ft. or so, but if there are any trees in the vicinity, a space about four times as expansive is necessary to clear them.

As regards landing an airplane, it is not unreasonable to suppose that the power of vertical descent may ultimately be achieved. From the outset it appears that the helicopter must essentially be less efficient than the airplane as a power-absorber. A helicopter may be regarded as a practical combination of two fast-climbing airplanes united wing-tip to wing-tip and facing in opposite directions. An airplane ascending on a spiral path fulfils in the main the primary function of the helicopter, viz., ability to raise a load vertically. When the spiral path or helix is visualized as stretched out to become a straight horizontal flight path or trajectory, the superiority of the airplane over the helicopter is obvious. As regards hovering flight, it does not seem that the helicopter would serve many useful purposes in that condition. A passenger in a hovering helicopter would seem to be related to one who might charter a special train to take him to Charing Cross or any other railroad bridge to remain stationary on the bridge while he enjoyed the view of the river.

A Possible Line of Thought

When one considers any proposal for a helicopter the first step generally is to make a mental comparison of the possible efficiency with that of an airplane. Bevel gears will generally be found in helicopter propositions and not in airplanes. It is not unlikely that the inefficiency which characterizes the use of heavy gearing will be eliminated by causing the whole structure of the helicopter to rotate.

Large triplane wings set at a dihedral angle commensurate with the centrifugal stresses may be rigidly braced to a central vertical body structure about whose virtual axis they would rotate under the action of airscrews and engines carried on the wings or in a reverse direction with the engines out of action. Inside the rotating central body the pilot would be supported on a horizontal platform caused to rotate in the opposite direction by a small auxiliary engine. He would then have no rotary motion. The machine could be supported on an annular float. This ring-shaped float, being rigidly connected to the helicopter, and therefore rotating, would offer only frictional resistances on the water, and a cross-section in a vertical plane at any radius would have approximately a pear shape with the blunter end uppermost. On this float an endless train for accommodating passengers might be driven round in the opposite direction to the general rotary motion.

Through the tapering lower end of the central vertical body structure there might project a vertical telescopic member, on the lower end of which the controlling airfoil would be carried. The pilot would have facilities for extending and contracting this telescope, so that the moment of the air-pressure on the airfoil about the center of gravity might be changed and utilized for balancing the machine or for tilting it to obtain a component for horizontal motion. A similar telescopic member might be carried above, projecting through the upper end of the vertical body structure. On the other hand, it might be better to carry only a parachute in that place, for emergency purposes.—Douglas Shaw in *Aeronautics*.

ORDNANCE MUSEUM

A MUSEUM is being established at the Aberdeen (Md.) proving ground to exhibit enemy material used during the World War. This exhibit consists of about 60 pieces and was obtained from the various battle fronts by representatives of the Ordnance Department. It is known as the Engineering Collection. Descriptive pamphlets, drawings and photographs of each type are being made for the purpose of study. It is also contemplated to arrange for experimental firings of this enemy material. Further, it is contemplated to supplement and extend this collection by adding to it types of United States Army material, such as experimental pieces and obsolete service types, many of which are now available and are being brought from Sandy Hook proving ground.

Automotive Radiators

By Karl F. Walker[1]

SINCE the publication of this article in the December, 1920, issue of The Journal, a written discussion has been received from E. H. Lockwood. This discussion and the author's reply are given below. For the convenience of the members a brief abstract of the paper precedes the discussion.

ABSTRACT

THE essential elements of an automatic cooling system are known to all engineers, but the importance and correct functioning of the various units of such a system are more or less vague to many. During the war the Bureau of Standards obtained considerable information on aeronautic radiators, but only a relatively small amount of information is obtainable on cooling systems for various other commercial uses.

When the spark ignites the gasoline vapor in the cylinder of an internal-combustion engine, the temperature may rise to about 2800 deg. fahr. and, in another moment, at the end of the intake stroke, the temperature may be only 300 deg. fahr. The mean temperature of the cycle will range from about 900 to 1000 deg. fahr. The effect of these temperatures on cast iron or steel, expansion, preignition, lubrication and the like, necessitates a means of cooling for which water has been found most satisfactory.

For such a cooling system the essential elements are a radiator, cooling fan, water-jackets and a means of water circulation. The factors controlling the heat flow to the water-jackets are the size and shape of the combustion-chamber, the thickness of the cylinder walls, the mean effective pressure of the engine, its cycle, speed and thermal efficiency. Proper circulation through the water-jackets in a pump circulating system is more important than the quantity of water contained therein, since lack of circulation in any one part of the jacket will cause overheating.

Radiator core construction is then discussed in some detail and a description of different types of cooling system is given. One of the most important factors affecting radiator performance is the air velocity through the core and this subject is dwelt upon in considerable detail. The subjects of cooling fans and general design factors are presented. The paper is illustrated with photographs and charts.

THE DISCUSSION

E. H. Lockwood:—The author of this paper has given practical hints of considerable interest and value on radiator design. Nevertheless, it is doubtless true that the constants and data relating to this subject are still incomplete and faulty. Evidence of this is found in some of the constants given in the paper as representing the practice of an important manufacturer, which differ from the corresponding figures obtained by other experimenters.

One questionable point, lying at the foundation of radiator design, is the percentage of the heat generated in the cylinder that must be dissipated by the radiator. This comparison is made on the basis of the heat generated at full load, and the maximum heat dissipation of the radiator. The author makes the usual assumption, based on block tests of engines, that from 25 to 40 per cent is dissipated by the radiator. Tests of many automobile radiators that give satisfactory cooling show a heat-dissipating capacity of only 15 to 18 per cent of the heat generation at full load. The reason that the smaller percentage of heat dissipation can be used successfully is due partly to the assistance of the fan in air-cooling the engine, and partly to the very limited periods when full power of the engine can be applied, thus never taxing the radiator with full heat dissipation. If it is true that radiator heat dissipation of from 15 to 20 per cent of the heat generation at full load is sufficient for automobile practice, the usual figures can be reduced considerably.

Another questionable point in radiator design is to be found in the constants for heat dissipation per square foot of radiation. The author gives these constants in the form of a diagram, Fig. 6, which shows average values for several types of core, varying with the depth of core and adapted to air velocities of 1800 ft. per min. for trucks and 4000 ft. per min. for passenger cars. Two criticisms properly can be made of this diagram. The air velocities are too large for either truck or passenger cars, and the same constants cannot be used for all the different kinds of core. On the first point, it can be assumed safely that a car speed of 55 m.p.h. would be required to produce an air velocity of 4000 ft. per min. through the core. The variation of heat dissipation from different kinds of core is considerable. Water-tube radiators with continuous fins have about 15 per cent direct cooling surface and 85 per cent of indirect or fin surface. The fin surfaces cool down at high air velocities and lose much of their efficiency. On the other hand, the horizontal air-tube core has 100 per cent direct cooling surface, and the heat dissipation per square foot of surface is double that of the fin-and-tube type.

There is need for a table of heat dissipation constants for various types of core, based on experiments over a considerable range for air velocities, water velocities, temperatures, and the like. Probably much of this work has already been done in various laboratories, and would be available for compiling such a table of constants.

Tests have been made at the Mason Laboratory of the Sheffield Scientific School, Yale University, of a variety of automobile radiators. In some cases tests have been made also on the engines for which the radiators were designed. A typical example, having some bearing on the points under discussion, is found in the Ford engine and radiator. The standard Ford tube and continuous-fin core was found to dissipate 46,000 B.t.u. per hr. when operating under thermosyphon circulation at an air velocity of 1800 ft. per min. through the core. By dynamometer test the Ford engine was found to develop 18 b.hp. with a fuel rate of 0.85 lb. per b.hp. per hr. This corresponds to a heat generation in the cylinders of 18 x 0.85 x 19,000, or 290,000 B.t.u. per hr. The ratio of heat dissipated by the radiator in this case is 46,000 divided by 290,000, or 16 per cent. This radiator had an actual radiation surface of 65 sq. ft., including both sides of the fins. Its heat radiation per square foot was about one-half that given by the lower line of Fig. 6, but the lower value is explained partly by the thermosyphon circulation of the water.

Karl F. Walker:—It is possible that the percentage of heat to be dissipated by the radiators of passenger

[1] M. S. A. E.—Chief engineer, Fedders Mfg. Co., Inc., Buffalo.

cars may be reduced somewhat, due to the fact that there are limited periods when full power of the engine can be applied. The percentages given are general, to cover various climates including those where conditions are severe. Some manufacturers use deeper radiator cores on cars to be operated in California and similar places. By so doing they obtain 10 to 15 per cent greater heat dissipation than is necessary for their Eastern trade. In truck and tractor design it is believed that these percentages are not too high, as they often operate under full load for comparatively long periods.

Professor Lockwood states that tests on passenger-car radiators giving satisfactory cooling show a heat-dissipating capacity of only 15 to 18 per cent of the heat generated in the cylinders. Engineers and automobile builders differ greatly as to what satisfactory cooling is. For example, there are two cars which use the same make of engine and carbureter, the same make and size of cooling fan and the same make of radiator; in short, the essential units are all identical. One of these builders requires about 15 per cent greater cooling surface than the other and claims he cannot get satisfactory cooling with less; yet the builder using the smaller cooling surface claims he has tested his cars in various localities and finds the cooling satisfactory. Another case at hand concerns two firms building cars of approximately the same price, which contain engines of the same type, the same number of cylinders and the same bore and stroke. The radiator on one of these cars is capable of dissipating 50 per cent more heat than the other. The engineer in this case is at present contemplating a change in the radiator to increase the cooling capacity still more, claiming that the present cooling is unsatisfactory. These are only two cases out of a number that illustrate how greatly engineers differ on what constitutes satisfactory cooling.

It is granted that 1800 ft. per min. is a higher air velocity than that obtained on the average truck or tractor; yet it is believed to be both a practical and desirable air velocity to maintain. The point was made that engineers were not giving due consideration to the importance of air as an aid to cooling. Using properly designed fans of ample diameter and having them correctly driven, there should be no difficulty in obtaining a velocity of 1800 ft. per min. through the average cellular or tube and horizontal-fin type of core.

Regarding an air velocity through the core of 4000 ft. per min., I believe that this is obtainable at a somewhat lower road speed than 55 m.p.h., if proper means are provided for the escape of the warm air from under the hood. However, a curve for an air velocity somewhat lower than 4000 ft. per min. would be of value for approximating radiator sizes for the few cars that are unable to obtain a road speed of from 50 to 55 m.p.h.

A table of heat-dissipation constants for various types of core under varied conditions would undoubtedly be very interesting. However, it must be remembered that in the manufacture of ribbon types of core the width of the water passage varies, due to the degree of hardness of the brass, the condition of the forming dies and similar factors and, as a result, the heat dissipation of two cellular cores of the same type made in the same factory may vary by as much as 15 per cent. The constants of the heat dissipated per square foot of radiation are only average values obtained from tests on a number of different types of core and are only valuable as an approximation.

Professor Lockwood states that, at high air velocities, a horizontal air-tube core having approximately 100 per cent direct cooling surface dissipates about 100 per cent more heat per square foot of radiating surface than a core of the tube and continuous-fin type having about 15 per cent direct cooling surface. Of course, these are two extreme designs of core construction. However, it is noted from tests run at the Bureau of Standards on a tube and continuous-fin type of core $3\frac{1}{8}$ in. deep and having 12.3 per cent direct cooling surface, that the core dissipated 28.3 B.t.u. per sq. ft. per min. at an air velocity through the core of about 3200 ft. per min. It was noted further that the tests on a 3-in. hexagon-shaped single-tube core showed the dissipation to be 30.4 B.t.u. per sq. ft. per min. for the same air velocity. In this case we find that the core containing the larger amount of direct surface dissipated only 7.5 per cent more heat per square foot of surface than the one containing the smaller amount of direct surface.

Undoubtedly, the low heat dissipation of the Ford radiator tested at Yale University was due to the fact that it was tested under thermosyphon conditions. It was found that this radiator dissipated only 16 per cent of the total heat generated in the cylinders. Again it is a case of what constitutes satisfactory cooling. Professor Lockwood assumes that this radiator gives satisfactory cooling, but it is often found in driving Ford cars in hilly or sandy countries that the cooling is not ample. Tests run with a Ford car by the Motor Transport Corps through some hilly and muddy country necessitated the use of about 5 gal. of water on a 100-mile test run.

STATICAL LONGITUDINAL STABILITY OF AIRPLANES

REPORT No. 96, which has recently been issued by the National Advisory Committee for Aeronautics, Washington, is a continuation of the Committee's report No. 70, which was a Preliminary Report on Free Flight Testing. A detailed theoretical analysis of statical stability with free and locked controls is presented in the later report together with the results of many free flight tests on several types of machine. The results of these tests with locked controls are discussed and it is pointed out that the experimental results and those which might be theoretically expected are in agreement.

The theory of stability with free controls is not amenable to the simple mathematical treatment used in the case of the locked controls, but a clear statement of the conditions enables several conclusions to be drawn, one of which is that the fixed tail surfaces should be much larger than the ones which are movable. The discussion of the flight tests with free controls covers the effect of the position of the center of gravity, tail setting and slip-stream on the JN-4H plane. An analysis of the curves of forces on the control stick for the VE-7, U S A C-11 and the Martin transport airplanes is given.

Members who desire a copy of this report can secure one by writing the National Advisory Committee for Aeronautics, Washington.

Torsional Strength of Multiple-Splined Shafts

By C. W. Spicer[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

VARIOUS theories have been advanced regarding the torsional strength of multiple-splined shafts. So far as I am aware there are very little available published data on the subject. The results of some recently completed tests will, therefore, be of interest. In preparing this data it is intended to describe only the actual tests, the conditions under which they were carried out and the results obtained. No attempt will be made to develop the theory involved.

Superficially, it would seem obvious that the torsional strength of a multiple-splined shaft would probably be greater than that of a full round shaft having a diameter equal to the small diameter of the splined shaft. Data on this and related questions were sought experimentally.

A series of tests was run on 15 carefully machined shafts, as indicated in Fig. 1. The dimensions shown are the actual ones of the test-pieces, there being not more than 0.0005-in. variation in any shaft from the diameters shown. Heat-treating was very carefully carried out, and each specimen carefully checked by Brinell instrument on the ends and by scleroscope throughout the length. The Brinell numbers were all between 220 and 235, and the extremes of scleroscope hardness were 38 and 43. It was at first intended that the small diameter of shafts Nos. 1 to 5 should agree exactly with the small diameter of shafts Nos. 6 to 10. It was decided after the heat-treating had been done to avoid any straighten-

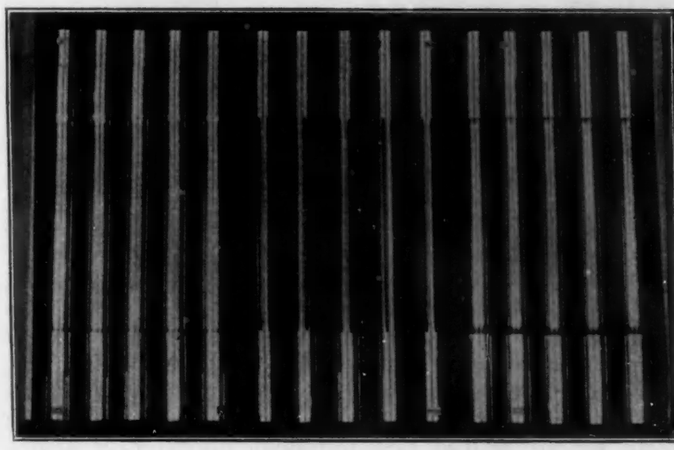


FIG. 2—THE 15 SHAFTS WHICH WERE TESTED

[1] M.S.A.E.—Vice-president and chief engineer, Spicer Mfg. Corporation, South Plainfield, N. J.

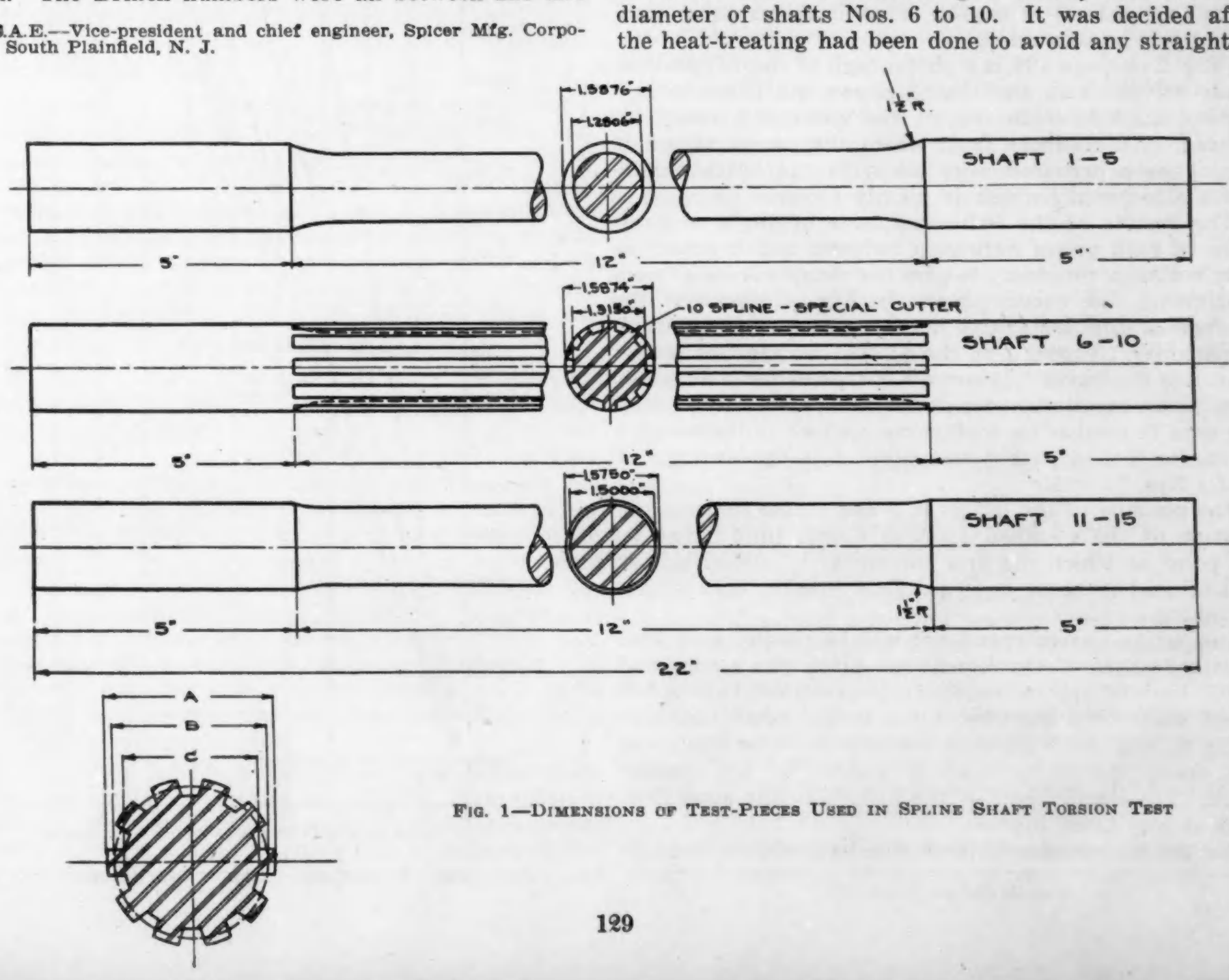


FIG. 1—DIMENSIONS OF TEST-PIECES USED IN SPLINE SHAFT TORSION TEST

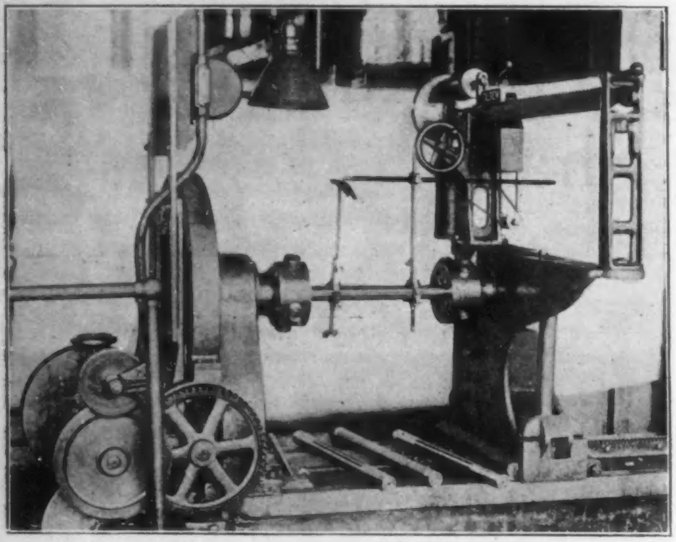


Fig. 3—The Testing Machine Employed

ing operations and, therefore, the small diameter of shafts Nos. 1 to 5 was reduced to a size that would clean up the most badly warped shaft by grinding. This also accounts for the large diameter of shafts Nos. 6 to 10 being below the 1⅝-in. nominal diameter. However, none of these details materially affected the results, as will be seen later.

It will be noticed that the small diameter of shafts Nos. 11 to 15 lies between the large and the small diameters of shafts Nos. 6 to 10 in approximately the relation shown in the lower left corner of Fig. 1 on page 129. This diameter represents a shaft which, according to one authority, is hypothetically equivalent to the splined shaft in torsional strength. That it is far from equivalent will be seen later.

Fig. 2 on page 129 is a photograph of the 15 specimens ready for the test and Fig. 3 shows the Olsen torsion testing machine with one of the specimens ready for testing. All readings from which the curves shown in Fig. 4 were prepared were taken by the Olsen troptometer attachment, which is plainly shown.

The results of the individual tests of the five specimens of each group were very uniform and it therefore does not seem necessary to give the detail curves of each specimen. The curves shown in Fig. 4 represent the average of the five shafts in each group, and are self-explanatory. Curve *a* is the plotted average of shafts Nos. 1 to 5. Curve *b* is curve *a* corrected for a diameter equal to the small diameter of shafts Nos. 6 to 10 for convenience in comparing with curve *c* which is the average of shafts Nos. 6 to 10; and curve *d* is the average of shafts Nos. 11 to 15.

The position of the letters *a*, *c* and *d* also indicate the location of the so-called Johnson elastic limit; that is, the point at which the unit increment of deflection per unit of load increase is 50 per cent greater than at the beginning.

Comparing curves *b* and *c* it will be readily seen that a splined shaft of the dimensions given has a torsional elastic limit of approximately 18 per cent less than a full round shaft of a diameter equal to the small diameter of the splined shaft although the deflection for any given load below the elastic limit is greater in the smaller shaft. The elastic limit of the hypothetically equivalent shaft is very much higher.

For the convenience of those who have not studied tor-

(*Concluded on page* 199)

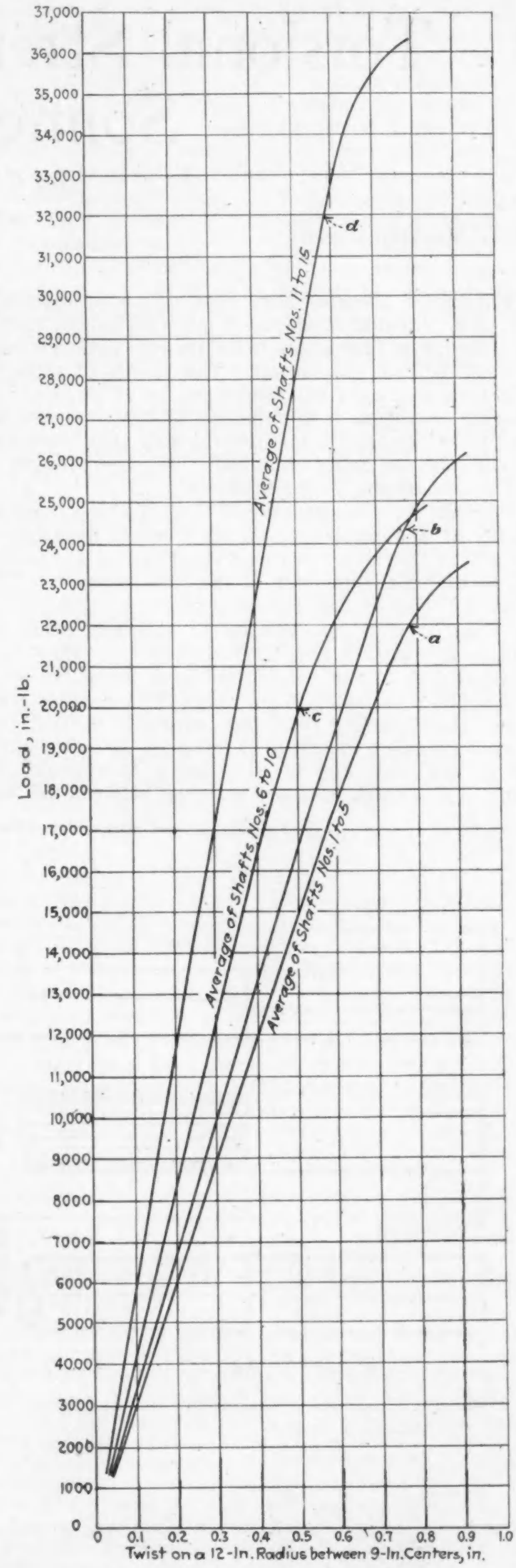


Fig. 4—Composite Curve of Test Results

Notes on Current Fuel Research

On Nov. 8 letters were sent to a number of members interested in the internal-combustion engine fuel problem. These letters propounded several questions relating to the problem which the members were requested to answer. The questions and some of the replies that were received in response to the letter are given on this and the following pages.

What line of development or research are you following now in connection with fuel study? Why have you selected this particular means of solving the problem?

R. J. BROEGE:—We are concentrating our efforts on improving the vaporization of gasoline fuel by applying the hot-spot manifold system, since it seems to be the most logical method adaptable to the constant-volume engine using gasoline as a fuel.

O. B. ZIMMERMAN:—The chemical treatment of fuels to reform their molecular structure is being prosecuted because experiments have shown that such processes are effective and provide more suitable fuel, at no increase in cost.

P. S. TICE:—Both a qualitative and quantitative examination of the conditions surrounding the formation of the working charge is being studied, with respect to vapor content in the charge and final temperature of the charge. This study is being made because, aside from certain inherent chemical differences among fuels, their satisfactory use in an engine is almost wholly a problem in charge formation.

D. FERGUSSON:—We have, of course, experimented with various methods of using the high end-point fuel that is now on the market. These have consisted of hot-spot intake manifolds, water-jacketed manifolds, manifolds jacketed with exhaust gases, and devices similar to the fuelizer. We have not at present obtained any results that would warrant us in changing from our standard equipment of water-jacketed manifold, with a thermostat cutting out the radiator when the temperature of the water in the jacket gets below 160 deg. fahr.

L. M. STELLMANN:—Practically all of our development work in connection with the adaptation of present fuels to our air-cooled engine has been toward the utilization of exhaust heat on the exterior of the intake manifold. The greatest portion of the heat is applied above the center of the manifold, where the largest amount of the mixture of air and fuel is encountered as it goes into the cylinders. The heater is arranged so that, as heat passes toward the extreme ends of the intake manifold, the temperature is reduced approximately in proportion to the amount of mixture encountered. The amount of heat used in connection with this intake-manifold heater is controlled from the seat by the operator, and it is possible to use the entire exhaust gas from three cylinders of a six-cylinder engine.

In connection with cold-weather starting, we have developed an electric vaporizer or starting carbureter in which air and gasoline are passed over an electrically heated coil. This mixture of heated air and gas is passed into the intake manifold above the throttle-valve and consequently under a comparatively high vacuum. We find that an engine can be started with this device by using kerosene, or at least a very low grade of gasoline, under temperature and climatic conditions reaching 20 deg. below zero fahr. Flooding the engine badly, when starting under cold-weather conditions, is overcome by the use of this electric vaporizer in combination with the rapid warming of the incoming charge by the use of a large amount of exhaust heat about the intake manifold. These two methods have practically eliminated crankcase dilution and consequent piston, cylinder and bearing wear.

It seemed most desirable to use the heat in the exhaust to raise the temperature of the incoming charge, vaporize it more fully and bring the overall efficiency of the gasoline engine nearer that attained under warm-weather operating conditions.

G. A. GREEN:—We have been developing a method of thermostatic inlet temperature control because we believe that we can effect greater economy in this way with less direct expense and inconvenience than in any other manner.

HUGO C. GIBSON:—We have been studying the use of heated intake-manifolds provided with exceptionally large surfaces in their interior, where those portions of the fuel having a high boiling point can be caught and slowly evaporated on the heated surfaces without excessive addition of heat.

The mixture becomes somewhat hotter than is necessary with low end-point gasoline and necessitates the use of decreased maximum compression to avoid autoignition. Since there is no liquid fuel within the cylinder, cracking and detonation are avoided. This results in somewhat decreased volumetric efficiency, but in increased general ability and smoothness, considering the character of the fuel available.

H. L. HORNING:—I am studying the subject of turbulence because it

(1) Is the factor we know the least about
(2) Controls flame propagation
(3) Deals with fuels as we find them
(4) Decreases the tendency to detonate
(5) Maintains a lower and more uniform temperature on the unjacketed sections of the combustion-chamber, such as the piston, exhaust valve and spark-plug
(6) Insures less after-burning
(7) Permits higher compression and hence high mean effective pressure and high thermal efficiency
(8) Means greater flexibility and acceleration
(9) Affords the most effective physical means of controlling all causes of thermodynamic losses

C. A. NORMAN:—I am following, so far as possible, all lines of research promising to lead to greater engine

economy or other relief in the fuel situation. Several general lines of development appear profitable to me.

The heated inlet-manifold does not avoid fuel waste, poor distribution, crankcase dilution and carbon formation during the starting-up period. The fuel converter seems to be superior in this respect. At car speeds of 20 m.p.h., the flame propagation from a single spark-plug does not carry combustion through the clearance space of even comparatively small engines. For a long time, two spark-plugs have been known to increase economy and power very materially; this fact should no longer be neglected. Increased compression in general leads to greater power and improved economy. Insofar as "doped" fuels permit increased compression without knocking, they should be encouraged. Nevertheless, to build up an entirely new industry and create a new source of expense to engine users to save fuel by increased compression, is not economically sound if some other means of increasing economy can be found.

The injection engine is one solution. Recent reports published in this country and Europe show that injection engines of automotive dimensions and speeds are within the realm of legitimate technical development. Steam offers the possibility of operation on any kind of fuel, with an economy that may prove fair at reduced loads.

Have you substantiated any new and interesting engineering facts related to the fuel problem since the Summer Meeting?

C. A. NORMAN:—The facts that have come to my attention since the Summer Meeting of the Society emphasize more than ever the possibilities of the injection engine.

O. B. ZIMMERMAN:—It is possible to handle any known liquid fuel obtained from natural mineral resources, even asphaltic fuels, with returns of 76 per cent, where former processes produced only 15 per cent from the crude. Kerosene, gas oil, fuel oil, residue and crudes of all kinds, can be treated by this process.

R. J. BROEGE:—We have developed a special exhaust-jacketed manifold of our own design, using kerosene as a fuel in the gasoline engine with slightly lower compression. Gasoline is used as fuel for starting.

HUGO C. GIBSON:—The turbulence theory is a red herring across the trail. The detonation theory, with the assumption that the more rapid the rate of flame propagation is, the greater the noise will be, is incorrect because very high-test gasoline, or benzol, each giving an exceptionally high rate of flame propagation, does not detonate, the benzol being inherently less subject to detonation than the gasoline. In other words, these high-grade fuels are less subject to detonation, or knock, or auto-ignition, as it really should be called, because the temperature at which they will ignite automatically is much higher in the case of benzol and high-test gasoline than in the case of low-grade gasoline or kerosene in the order named.

What is your present practice on compression pressures, using gasoline, kerosene or benzol?

L. M. WOOLSON:—Our testing work is confined to gasoline. On our small-bore passenger-car engines we are using 70 to 75-lb. per sq. in. gage compression, measured at 120 r.p.m. On our larger truck engines, we are using compression pressures between 55 and 60 lb. per sq. in. On our aviation engines, we use between 110 and 120-lb. per sq. in. compression, measured in the same way.

P. S. TICE:—For gasoline, we use from 85 to 95 lb. per sq. in., and for kerosene from 70 to 75-lb. per sq. in. gage compression.

L. M. STELLMANN:—We use a compression of about 70 lb. per sq. in. with gasoline. With kerosene, the compression under the same conditions would not run over 60 lb. per sq. in. With benzol, the pressure probably would be as high as 80 lb. per sq. in. We have found that benzol practically will eliminate preignition or detonation, even under the highest operating temperatures encountered in our air-cooled engines.

C. A. NORMAN:—Given a correct design of head and inlet passages, 60 to 65 lb. per sq. in. compression would appear to be possible with kerosene; with gasoline, it would reach 70 to 80 lb. per sq. in. With lighter gasolines and efficient cooling, very much higher compressions are known to be practicable.

HUGO C. GIBSON:—Depending upon some elements of design of the engine, such as the cylinder capacity and the relation of the bore to the stroke, the following gage pressures give good results, the pressures being determined accurately with an O'Kill indicator or manograph at 800 r.p.m.

	Pressure, lb. per sq. in.
Gasoline	65
Kerosene	55
Benzol	100

H. L. HORNING:—We have no established practice as yet. With each improvement in turbulence we increase compression pressures. We are not so interested in compression pressures as compression ratios. We use the same compression ratios now for kerosene as gasoline, namely 4 to 1.

R. J. BROEGE:—The compression pressure depends somewhat upon the size of the engine. For our smaller engine, the compression ratio is approximately 4 to 1, giving about 75 lb. per sq. in. gage at 125 r.p.m., and the largest engine is arranged with $3\frac{3}{4}$ to 1 ratio or about 65 lb. per sq. in. gage at 125 r.p.m. These compressions are reduced approximately 20 per cent for kerosene.

G. A. GREEN:—We employ 85-lb. per sq. in. compression when using gasoline.

Have you any definite recommendations on spark-plug location relative to the valve, cylinder center, or combustion-chamber?

H. L. HORNING:—Theoretically the plug should be (*a*) at the minimum distance from the hottest spots; (*b*) in the path of greatest turbulence; (*c*) toward the center of gravity of the combustion-chamber; and (*d*) if possible, pocketed rather than opposite a pocket. All these points should be considered as the introduction of turbulence changes the controlling factors greatly. In a mixture free, or relatively free, from turbulence the detonation phenomena are shown plainly by flames in a glass tube, while a turbulent mixture tends to control these phenomena, including retonation and reflected sound waves. At low speeds the phenomenon of combustion in a cylinder tends to obey the properties of burning gases in a tube, while at moderate speeds turbulence controls flame propagation and at high speeds it prevents any local rapidity of flame propagation but enflames the whole mass in a minimum time, assuring the highest temperatures with the minimum dissociation. At high speeds turbulence is a maximum and tends to overcome the defects of decreasing volumetric efficiency and mechanical efficiency by improving the efficiency of combustion.

HUGO C. GIBSON:—The cylinder center is the preferred position, meaning in the center of the head.

P. S. TICE:—In a combustion-chamber having small temperature gradients spark-plug electrodes should be located as near as possible to the center of mass of the compressed charge. Where the combustion space has very hot parts or pockets, the spark-plug should be located in the hottest part.

R. J. BROEGE:—The spark-plug location should be nearly central in the combustion-chamber and at a point centrally between the piston and valves, so that the exhaust and also the incoming gas sweep across the points of the plug.

L. M. WOOLSON:—Although we believe that the spark-plug location has an important bearing on detonation, the best location must be determined experimentally for each particular design of engine.

L. M. STELLMANN:—We have gone rather extensively into the location of the spark as well as its time of action. Using a hairpin-electrode plug we were able to place the spark at the center of the combustion space and close to the piston. A careful road test showed that locating the spark at the center of the combustion space required 7 deg. less advance at 20 m.p.h. than was required under the same conditions when using a standard short plug. An automatic advance was then used and road acceleration tests were taken at intervals of 5 deg. of advance or retard from the original position. Our tabulated results indicated clearly that a variation of 5 deg. in advance was important and should be considered when maximum performance was desired.

O. B. ZIMMERMAN:—The plug should be cooled by the incoming gases and a location near the center of the gas to be ignited is beneficial.

C. A. NORMAN:—From the point of view of economy and power, as well as avoidance of knock, spark-plugs ought to be centrally located for a minimum distance of necessary flame travel. Naturally, the points should be swept by the fresh charge. Captain Hallett and H. R. Ricardo have pointed out that a hot exhaust valve at some distance from the spark-plug is apt to cause a knock. It is better to have the inlet farther from the spark-plug than the exhaust valve, if a central location between the valves is not possible. Mr. Ricardo in a recent paper[1] states that the increase in power obtainable by using two spark-plugs can always be equalled by sufficient spark-advance with a single spark-plug. With compression as high as feasible, too great spark-advance will in time mean knock. Multiple spark-plugs, according to Ricardo, give greater flexibility without spark adjustment, and indirectly greater power and economy by making increase in compression possible. Captain Hallett, as well as many earlier experimenters, however, states categorically that increases in power of something like 11 per cent can be obtained by multiple spark-plugs.

Have you succeeded in developing a means of increasing compression without resultant detonation?

L. M. STELLMANN:—We cannot hope to increase compression indefinitely without experiencing detonation. An extensive series of spark-plug tests was run in our laboratories with the following results.

In the first series we tried a long heavy plug with a skirted extension. This plug fired perfectly for ½ hr. after the electric ignition was cut off. From this point the preignition decreased as the metal was removed from the skirt until the skirt vanished. In another series we used heavy hairpin plugs 1/16 in. in diameter. The preignition then decreased with a decrease of the diameter of the wire. With a compression ratio of 4.8 to 1 we found that wire of 0.030-in. diameter burned fast at the points of spark passage. A wire of 0.040-in. diameter did not cause any preignition except under very adverse conditions that would be seldom encountered.

R. J. BROEGE:—It has been our experience that the limitation of compression is governed greatly by the composition of the fuels used and that detonation can be held to the minimum by properly cooling the combustion chamber and the head of the piston.

HUGO C. GIBSON:—We feel that the allowable compression is determined by the specific temperature at which the fuel mixture will automatically ignite.

C. A. NORMAN:—In injection engines the knock does not figure. Personally, I prefer to lay emphasis on this fact, not because I am not keenly interested in developments making increased compression and better economy possible with carburetted engines, but because there is not a sufficient number of engineers in this country today who strive to keep the possibilities of injection engines before the eyes of the profession.

Have you applied the turbulence theory effectively and what provisions did you make to create or maintain turbulence?

P. S. TICE:—Yes. We recommend localizing the combustion space as much as possible over the valves in an L-head engine, constricting the passage fairly well from this space to the cylinder bore proper, and forming the localized combustion space to conform as nearly as possible with what are supposed to be the general flow lines of the charge as it is compressed into this space.

C. A. NORMAN:—Turbulence should be created not only by velocity through the valves, but by special means, during ignition and combustion. Various ways of doing this have been suggested, and a number are successful in related fields.

L. M. STELLMANN:—We have not been able to prove to our own satisfaction that the turbulence theory has any particular bearing on the performance of our engine. On the other hand, we do believe that overhead valve construction lends itself much better to the thorough turbulence of the charge.

O. B. ZIMMERMAN:—I consider that the shape of the combustion space and the method of entry are chiefly responsible.

H. L. HORNING:—Gas velocity and shape of combustion-chamber are the important considerations affecting turbulence.

Have you any information that you may disclose regarding intake-manifold and distribution phenomena?

R. J. BROEGE:—Our manifolding is so arranged as to produce the best vaporization at the point of greatest diffusion of the heavier particles in the fuel. We also endeavor to locate the hot-spot on the manifold as close to the intake valves as possible, to reduce volumetric loss and minimize increase of temperature.

L. M. STELLMANN:—We have found it desirable in connection with the intake manifold and distribution to keep the temperature of the fuel as distributed into each cylinder as nearly even as possible throughout the whole

[1]See *Engineering*, Sept. 3, 1920, p. 325.

engine and the gas should pass into the intake-valve port at a temperature of between 100 and 120 deg. fahr.

L. M. WOOLSON:—As a general proposition we have found with a six-cylinder manifold that it is very desirable to extend a baffle from the center of the manifold to a point near the carbureter so as to form two independent passages, one leading to the forward three cylinders and the other to the rear three cylinders. This eliminates loading, particularly at the lower speeds, and also effects important improvements in distribution. We have applied this idea to several different types of six-cylinder engines and can definitely state that such baffling is highly desirable.

HUGO C. GIBSON:—Based on my belief that turbulence and high velocity in the intake manifold are not desirable, and that a properly formed mixture of fuel vapor and air is what we require in the cylinder prior to compression, it is best to increase the size of the intake manifold with the result that restrictions are reduced and a torque curve flatness is maintained.

H. L. HORNING:—Proper velocities and investigation of shapes with glass models plus heated surfaces as per the S. A. E. Fuel Report enabled us to attain 0.60 lb. per hp-hr. consumption and 82 lb. per sq. in. m.e.p. on kerosene.

If you have experimented with "doped" fuels, please state what the results have been.

O. B. ZIMMERMAN:—There is considerable valuable work to be done along this line with net results of value, although most of the work is unnecessary while fuels are as obtainable as at present.

P. S. TICE:—We have done nothing whatsoever with "doped" fuels, inasmuch as others, notably Mr. Midgley, have been giving this aspect of the situation much attention.

L. M. STELLMANN:—One and two per cent mixtures of anilin oil with gasoline seem to make practically no difference in the running of our engine.

HUGO C. GIBSON:—Benzol mixed with gasoline is the only practical "doped" fuel at this time. It permits the use of higher compressions without knocking, because the temperature of auto-ignition is raised due to the presence of benzol. However, the use of benzol is not a solution of the problem, on account of the poor national distribution of that commodity. A benzol and gasoline mixture gives more power, greater economy, greater smoothness and more comfort than straight gasoline in any engine, the advantages being particularly noticeable in high-compression engines in which the mixture is not heated to a great degree as in the older type of engine. The advantage is not so marked in engine designs adapted to the use of the present high end-point gasoline.

H. L. HORNING:—Satisfactory results have been obtained in our experimental work with "doped" fuel.

UNITED STATES AIR MAIL SURVEY FLIGHT

AN exhaustive report of the United States Air Mail Survey Flight from New York to San Francisco undertaken by the Post Office Department July 29-Aug. 8, which has been prepared by one of the fliers, Lieut. S. C. Eaton, presents a number of interesting details. When it became known that the flight was contemplated, John M. Larsen, who was importing from Germany Junkers all-metal monoplanes equipped with the B. M. W. 185-hp. engine, offered the use of two of these planes and the services of his pilots at his own expense. This offer the Air Mail Service was glad to accept, by reason of its own limited appropriations, and explains the prominence gained by the J. L. 6 in this country, shortly after Bertram Acosta, flying one of these planes, made the American non-stop cross-country record flight from Omaha, Neb., to a point near Lancaster, Pa., a distance of 1090 miles.

The route selected was, practically, the one traversed by the Army Air Service Transcontinental Flight of 1919. In addition to the two planes offered by Mr. Larsen, the Army Air Service cooperated with the Post Office Department by sending along a J. L. 6 which it proposed to use for fire-patrol duty near San Francisco.

The personnel of the flight, at its take-off from New York were:

Post Office Plane No. 1—Pilot Bertram Acosta, former Curtiss test pilot; Mechanic Ernest Buhl, former B. M. W. factory expert.

Post Office Plane No. 2—Pilot Emil Mons, former German Junkers test pilot; Second Pilot Harold T. Lewis, Air Mail Service.

U. S. Air Service Plane No. 3—Pilot Capt. H. E. Hartney; Second Pilot Lieut. Charles Colt.

Upon reaching the first stop, Cleveland, it was deemed inadvisable to carry the German pilot on plane No. 2, and a telephone request was made to the New York office for pilot S. C. Eaton, who was employed as one of Mr. Larsen's test pilots, to take his place, and to bring along mechanic Charles Myhers to replace mechanic Ernest Buhl.

The passengers were: L. L. Lent, general superintendent of Air Mail Service; John M. Larsen, president J. L. Aircraft Corporation; E. E. Allyne, president Aluminum Manufactures, Inc., Cleveland; Eddie Rickenbacher, former captain Air Service, overseas, and J. A. Bockhurst, motion picture camera man, International Film Service Corporation.

The following control stops were provided and made use of:

Control Stop	*Height above Sea Level, ft.*	*Distance Between Stops, miles*
Mineola	106	
Cleveland	603	503
Chicago	593	307
Omaha	1,034	431
Cheyenne	6,062	455
Salt Lake City	4,248	387
Reno	449	431
San Francisco	15	187

The total mileage was 2,701, one detour being made, namely between Omaha and Cheyenne, to North Platte. The maps carried were an Air Service transcontinental map, a Post Office map, together with Rand & McNally maps of each State traversed.

Supplies requested at each stop were 200 gal. 90-per cent benzol; 200 gal. high-test gasoline; 50 gal. specification 35-35 oil.

The list of spares actually used was

Cleveland—Plane No. 1, several rocker-arms from Plane No. 3. Plane No. 3, washed out of flight and substitute flown to Cleveland from New York to continue flight as Plane No. 3.

Omaha—Plane No. 3, new wheel.

Cheyenne—Plane No. 2, new tire.

Reno—Plane No. 1, broken landing-gear; strut repaired by machine shop. Plane No. 1, one new tire.

San Francisco—Plane No. 2, new exhaust-valve spring.
—Air Service News Letter.

The Design Requirements of Commercial Aviation

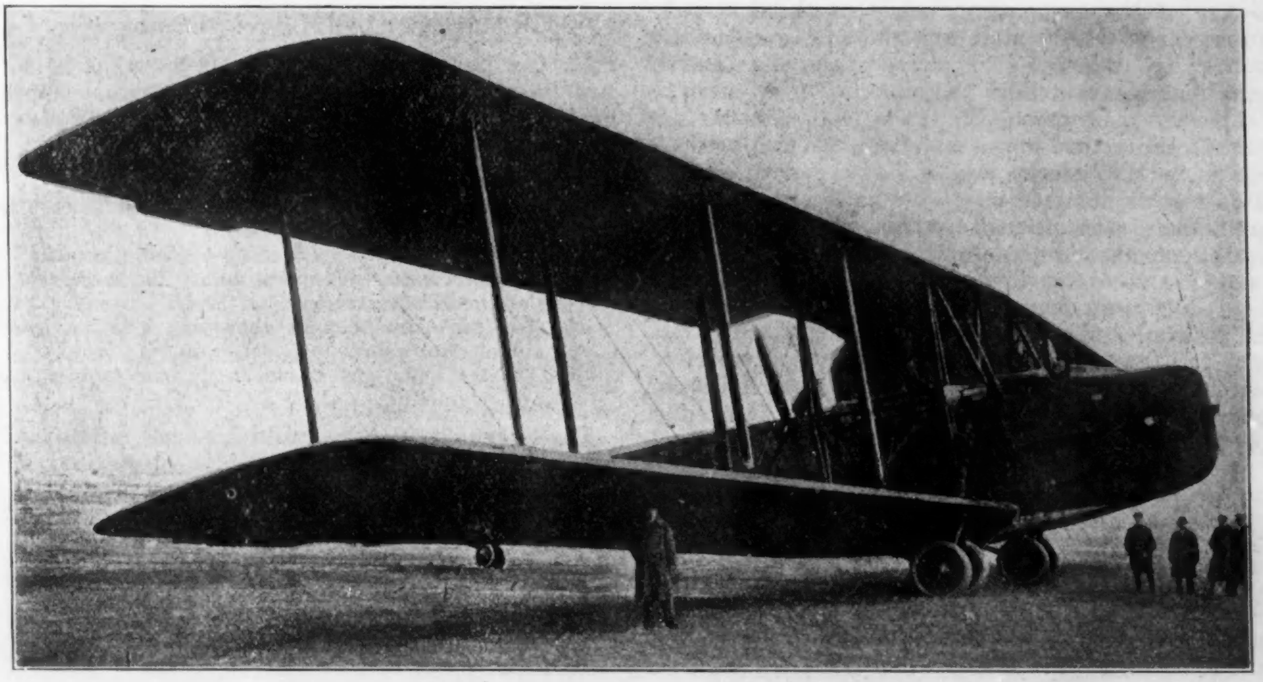
By Grover C. Loening[1]

Annual Meeting Paper *Illustrated with* Photographs and Drawings

THE general expectations for aviation progress that are voiced by the press and many technical journals, and in discussions among aeronautical people, consist largely of hopes, predictions and an apparently fervent desire for many radical departures. For no other reason than a lack of patience, the public seems dissatisfied with aviation unless it is constantly confronted with some exciting revolutionary step, usually widely advertised as the final solution of practical aviation. The past year gives one particularly glaring instance of this in the entirely unwarranted prominence given to the "all-metal" airplane, and the innumerable editorial comments and other predictions usually made by people unfamiliar with aviation on how this development had solved the "problem."

Many of us must admit that we do not really know what the "problem" is. Aviation problems, like the battle of Jutland, still are being fought out in considerable of a fog. But when the metal airplanes burned up as readily as any other machines and showed many other important disadvantages, sentiment turned too quickly. For example, a prominent New York business man commented upon this development to the effect that, since metal airplanes had been proven unsafe, what was there left that aviation engineers could do. As a matter of fact, the difficulties encountered in the Junkers type of monoplane have, in my opinion, led to a situation where many of its very desirable advantages having nothing to do with its metal construction have been completely overlooked. I particularly refer to the excellence of its engine and its aerodynamic qualities.

There are many such instances in the progress of aviation in which an unexpected realization of a radical departure leads to a full swing of the pendulum which, however, is only short-lived; for, when this radical departure suddenly is found to have been more or less unwarranted, the pendulum sweeps completely the other way to a keen sense of disappointment. Both extremes are wrong; the departure usually has some merit and teaches a valuable lesson. The story of the automatic stabilizer is a pertinent instance of this; four or five years ago it also had solved the "problem." Editorials predicted how the sky would be black with airplanes a few months after the automatic stabilizer had been perfected. A few people then had the temerity to point out that until the automatic stabilizer had become an automatic "lander," it had no real value, particularly as it was rightly expected that the control and inherent stability of airplanes would improve greatly. On the other hand, the automatic stabilizer has a very definite



The Siemens-Schuckert Bombing Plane Equipped with a Central Powerplant Consisting of Six 300-HP. Basse and Selve Engines

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A Bristol Single-Engine Biplane

and valuable use in connection with military aviation, particularly in bombing and navigating, although that is not the one for which it was originally intended. But, few automatic stabilizers are in use today commercially.

Because of the exaggeration of what these new departures will do at the start and the subsequent slump when they fail to meet their expected success, general appreciation by the public that successful aviation is here is tremendously damaged. If the public believes that aviation is impractical and unsafe as a general proposition, it is for the reason that it has been consistently educated to this point of view by aviation people themselves in their over-optimistic statements of what they think they can do. A plea for conservatism is realized now as being necessary to the successful prosecution of aviation. We must prove to the business man that we realize the time has come in the development of this art to stop "rainbow chasing." That is not only typical of commercial aviation, but it is even more evident in military and naval aviation; tactics are frequently evolved first and airplane constructors then are required to invent means of meeting them. The more practical basis would be to take what airplanes have been developed successfully and invent new kinds of tactics to make use of them. Tactics are easier to invent than airplanes.

Misdirected Aviation Development

On the basis of the experience we have had in the past two years the outstanding false leads that appear to have misdirected commercial aviation are as follows:

(1) The supposed advantage of huge multi-engined machines
(2) The unwarranted desire for slow-speed "buses" and slow landing
(3) The impractical applicability of war airplanes
(4) The unwarranted conception of the necessity of "all-metal" construction
(5) The mistaken thought that war aviation helped commercial aviation
(6) The too ambitious efforts to fly over bad country, and overselling

The arguments for multi-engined machines are

The DH 18 Equipped with One Napier Engine

THE WESTLAND LIMOUSINE AIRPLANE

generally known to all; if one engine stops, the other is supposed to keep the airplane going. As a matter of fact, in twin-engined machines having the engines out on the wings it has been found in the mail service that one of the most serious detriments to this type is that the engines stop nowadays more frequently from other causes than individual engine failure. For example, snow and frost on the engines disable both powerplants at the same time.

The use of multi-engined machines, in Europe, in comparison with single-engined machines, has disclosed no advantage. It has disclosed the serious fact that the machines are naturally larger, heavier and more cumbersome to handle on a field and much more expensive to operate. These difficulties are admittedly not as important in the large flying boat but, contrary to what was expected, all over the world the majority of new developments of commercial airplanes are single-engined machines. Obviously, the correct basis for consideration of this question is that presented by Frank Searle, who manages a London to Paris air line. He states that from the standpoint of reliability two engines are not better than one, simply because the one engine must be made absolutely reliable. Besides this, there is a totally mistaken idea in the mind of the public as to what causes engine failures on airplanes. It is very rare that the engine itself actually fails. Usually something fails in the gas line, a water line, or the like; so, the simpler and more direct installation of a single-engined unit is very advantageous.

From the standpoint of expense in maintenance, which constitutes the big charge in running an air transport line, where the big multi-engined machines require 15 to 20 men as a ground crew to handle them, three or four of these men could handle in the same time as many single-engined machines as there are engines in the big machine. It must be admitted also that the most expensive part of an airplane is the engine. The engine and its installation have always been, in the experience of many, the major cause of expense in maintenance work. In looking into the desirability of these large airplanes as compared with smaller and simpler ones, we should examine the very pertinent point as to the useful load carried per engine.

A BRISTOL TRIPLANE EQUIPPED WITH FOUR ENGINES

TABLE I.—USEFUL LOADS IN SINGLE AND TWIN-ENGINED AIRPLANES

Type	Single Engine	Twin Engines	Size, hp.	Weight Empty Including Water, lb.	Useful Load at about 9 Lb. per Sq. Ft., lb.	High Speed, m.p.h.	Useful Load per Horsepower Including Fuel, lb.
Fokker, V-45	185 B.M.W.	....	250	2,640	1,540	93	6.15
Avro Triplane	Six-cylinder Siddeley	....	245	2,460	1,220	96	4.97
Bristol Biplane	Six-cylinder Siddeley	....	245	2,650	940	108	3.84
Westland, 6-seater	Napier Lion	....	450	3,823	1,736	118	3.85
Central Aircraft	....	Beardmore	354	4,996	2,250	89	6.30
Vickers, "Commercial"	....	Rolls-Royce	700	7,790	3,267	103	4.68
Martin, "Transport" at 9 lb. per sq. ft. of surface	....	Liberty	800	6,800	3,289	110	4.10
Handley-Page, W8	....	Napier Lion	900	7,850	3,593	119	3.98

Table 1 presents a few figures on single and twin-engined aircraft; it is not in any way comprehensive, but indicates a very interesting result. In addition to the usual figures that have been given, a quantity entitled "useful load per horsepower" has been derived. It will be seen that even though the single-engined machines are largely related to war styles, with needlessly high safety factors, the fact remains that single-engined machines differ very slightly from multi-engined machines, all of those machines making about 110 m.p.h. and carrying somewhat around 4 lb. per hp. of useful load. The figures differ, of course, with the slower machine. For example: for the Fokker V 45, which is slower than many of the others cited, the figures at least show that any claim for a tremendously greater efficiency for multi-engined machines in carrying useful loads is entirely unwarranted.

A question then arises from a practical standpoint. Given the expense of 100 engines would a commercial aviation company have a more flexible organization and be less liable to loss by crashes if these 100 engines are distributed to 100 smaller airplanes or 25 larger airplanes; the net tonnage carried per year being the same, but the number of pilots naturally being increased? I believe the latter increased expense is offset very quickly by the fact that the smaller ground crews required for the single-engined machines would be kept busy all the time handling one single-engined machine after another; whereas the much larger ground crew required to handle the larger machines cannot be kept so busy and must of necessity be waiting for the arrival, departure or repair of the fewer large units. We can at least conclude that the much advertised solution of commercial aviation by the use of large machines has not materialized, and that the use of these machines has, in fact, raised a very serious question as to whether they are anywhere near as cheap to operate as the smaller units.

Regarding slow speed and slow landing, a paper was presented before the Society two years ago in which it was maintained that the raison d'être of aviation is speed. This continues to be the case, but at that time there was considerable argument to the effect that what aviation needed was not speed, but slow-speed "buses" that would lumber along in some old-fashioned way and were supposed to be desirable because they would be safer when landing. Slow speed does not always increase the safety of landing. This is particularly true of a machine that is very clean in design and speeds up fairly fast on a glide. If it is endowed with a low wing-loading in an effort to get a slow landing, it is likely to float interminably before it will actually stop rolling. To make slow landings high head resistance and low diving speed are needed, because the portion of a landing maneuver that uses up a field is the coasting of the airplane right near the ground, during the interval when it is endeavoring to stop flying and stick to the ground. At any rate, developments of recent machines have shown that a landing speed of 60 m.p.h. can be handled in a reasonable field, providing the machine slows up quickly after its wheels touch.

It is generally accepted now that the war types of airplane are not commercially applicable as easily as was expected. The airplane structure part of these machines is built with a much higher safety factor than is needed for commercial use. This involves an increase in weight that is distinctly uneconomical for commercial flying. Airplanes of one-half the safety factor of most war machines could be flown with safety. War-type machines were not in any way designed with a view to weathering qualities and, particularly on those types of machine on which veneer is used in the engine bed, where this is likely to get soaked with oil, and where small fussy parts requiring adjustment are hidden away in the fuselage and threads of too fine a pitch are easily crossed when roughly handled, the commercial airplane company runs into expenses in upkeep that are entirely unwarranted and which before long more than make up for the original lower price of the machine.

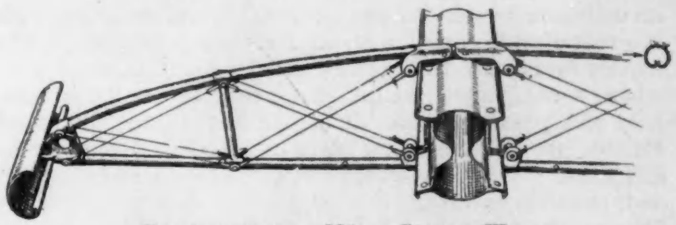
The smaller types of war machine do not carry enough load to make their expense seriously worth-while; the big machines are expensive, difficult to handle on a field and require expensive hangars. There are some types of naval flying boat that have been found distinctly useful, but principally because they require less alteration from a commercial standpoint in their installations. In the construction of war types of airplane, practically no thought was given to the protection of passengers and, above all, to the reduction of noise. Both of these features become of very great importance in commercial aviation, particularly the latter.

Are the engines used in war airplanes actually of a type at all suitable for commercial aviation? The lack of a muffler is by no means the most serious defect. The engines have generally such high compression that they bring with them endless spark-plug troubles. They are hard to start, difficult to cool and, particularly, full of minor carbureter and ignition difficulties. Many of their vital parts, such as the carbureter on the Liberty engine, are highly inaccessible locations and in many cases very dangerous from the standpoint of fire. The engines are in no sense commercial and were never designed as such. They, furthermore, possess several features calculated to

give performance at great altitudes. These features are not useless by any means, but are certainly not fundamentals that must be met in commercial aviation.

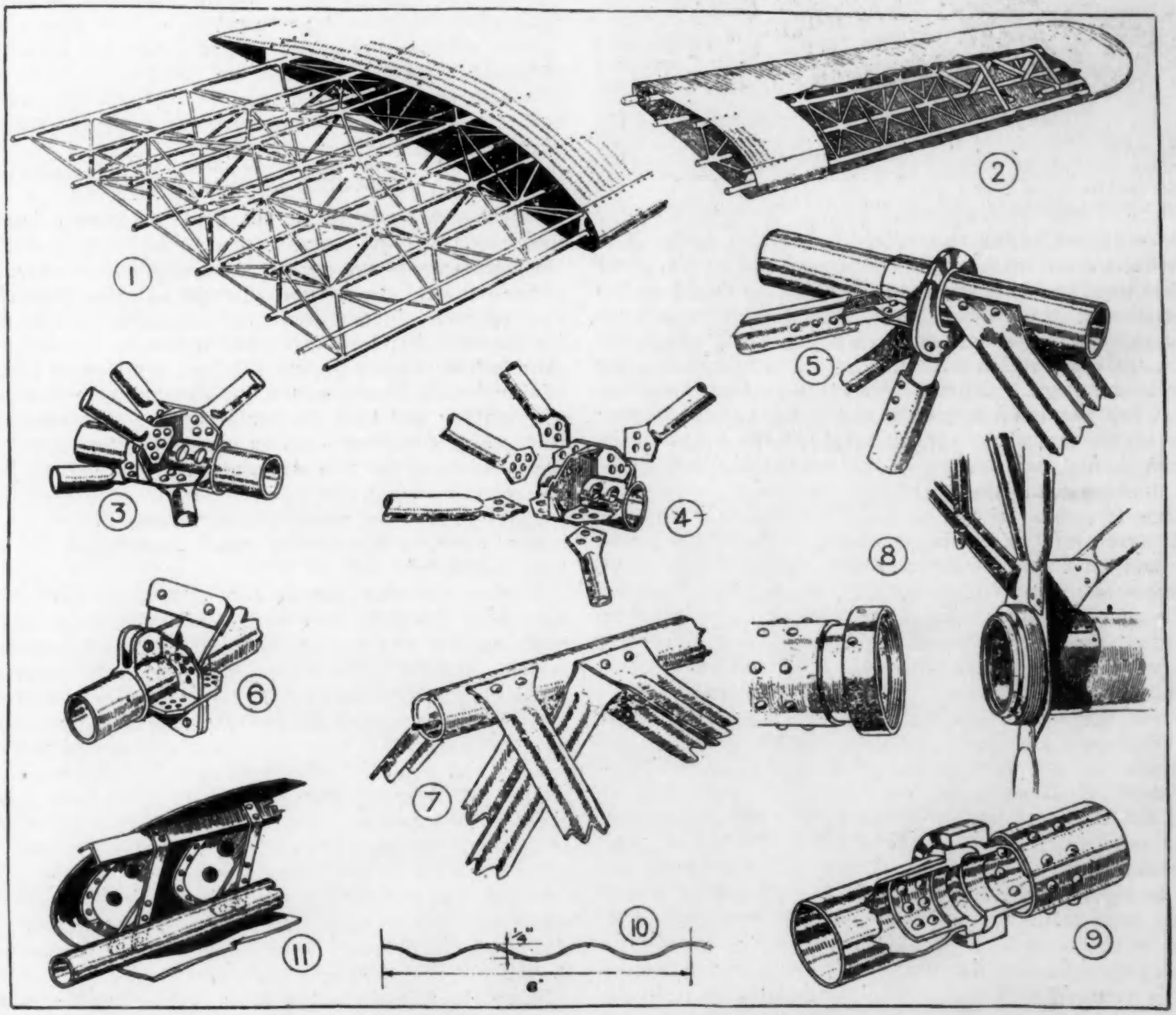
The most important feature that causes difficulties in using war airplanes commercially is the generally amateurish and inaccessible installation of the powerplant. Vital gas lines, filters and connections are generally hidden in out-of-the-way places; they are hard to see and in many instances difficult to replace. The reason for this is merely lack of development; the time for the production of a machine was short and these innumerable small details did not have the commanding importance on a war airplane that they have in commercial work. Constructors the world over have realized the inapplicability of war airplane types, and are busy designing new ones.

There has been much cry about "all-metal" construction and, opposed to this, considerable talk about "all-wood" construction. There is only one kind of construction that is really correct for an airplane; it is an "all-simple" construction, whether it be of wood, metal, paper or rubber. One false lead that has deceived many people is that metal construction is easier on quantity production than any other type. Based on con-



FRAMEWORK OF A METAL COVERED WING

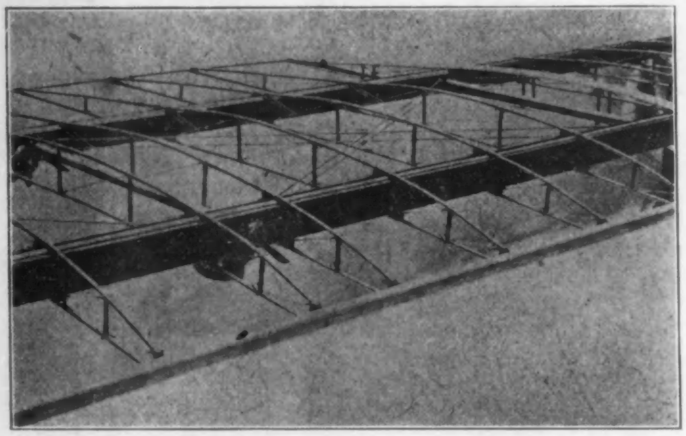
siderable experience in this kind of work, I venture to state that there is no more difficult type of construction for production in the small quantities in which airplanes are built than in metal, particularly "all-metal." The styles in airplanes, the load to be carried and the engines used, vary entirely too quickly to warrant the extremely expensive jigs and fixed equipment of tools needed to make metal construction economical. In addition, we have the serious situation today that metals are actually very hard to obtain, particularly in the light gages used on airplanes. This applies not only to duralumin, but to many grades of steel and steel tubing. But there are very notable instances in the details of airplane con-



SOME CONSTRUCTIONAL DETAILS OF THE JUNKER WING
1 and 2—General Construction of the Wing; 3 to 7—Details of Wing Braces; 8 and 9—Details of Wing Attachment; 10—Details of Corrugated Sheet Covering; 11—Detail of Leading Edge

struction in which the use of metal is apt to bring with it great simplification without increasing weight, and in almost every case this usually can be found in some part where a complicated metal fitting may be needed to take hold of a piece of wood. It is well known that the metal fittings are the expensive part of wooden airplane construction. When the wooden construction becomes more and more simplified, eliminating the number of small fittings, the necessity of metal construction becomes less urgent. It is possible to foresee in the general trend of development that the solution is a very judicious combination of the two, already reached in some new types of commercial airplane that have steel-tube fuselages and wooden wings.

One of the general arguments presented in favor of metal construction is the increased weathering qualities



A Linen Covered Wing Made with a Steel Framework

to be obtained. This is distinctly a false lead. The deterioration of linen-covered wings is not at all great on the linen itself; evidence of this can be found in the experience of the United States Navy, which has kept a squadron of large twin-engined flying boats absolutely out in the open at sea without very serious damage, for months at a time. What deteriorates in this construction is not the linen so much as the light glued veneer parts inside the wing. When strained these are likely to open seams, thus letting in the weathering and gradually disintegrating the structure.

There is ample indication that, given proper wooden construction on the inside of wings, with all the parts large and solid and few in number, a linen-covered wing will have plenty of durability for commercial purposes, with a veneer-covered wing a close second. It cannot be said that the veneer-covered wing is superior to the linen, when the ease with which the linen can be replaced in perfect order every few months is considered.

As for the metal covering of wings, what work has been done along this line has shown that the gages of the metal are so light that an extended use of the machine soon starts it cracking at the seams. The rivets pull out of the thin metal. The result is that after extended flights one can shake a handful of rivets out of the all-metal wing. The entire structure when built of metal is rigid, which is exactly the condition that is not desired on a metal frame in an airplane, because, as it is, the vibrations of the engine are harmful enough in their crystallization influence. But when a metal framework is covered with linen, the linen supplies exactly that quality of deadening shock which is greatly to be desired and likely to extend enormously the resistance of the metal frame to crystallization.

It seems possible to conclude from a general survey of standard practice at the present time that it is distinctly desirable to build fuselages of steel tubing, and particularly safe to do so around the pilots and passengers because, in the event of a crash, the fuselage members will buckle without splintering. Furthermore, it is found that for the same strength a metal-frame wing, linen covered, is heavier than a wooden frame, linen covered, by so large a margin as not yet to have justified itself. Many other parts of the machine, such as the landing chassis and the engine-bed, have for a long time been built of metal on various machines with entire success. The framework of rudders and fins on a large majority of airplanes have been built of steel tubing for years, so that there is nothing particularly new in a partially metal construction and absolutely no conclusive reason for abandoning linen as a covering material. New methods of doping have made linen much more weatherproof, but when we add to that more recent developments in making this covering absolutely fireproof, it is likely to come back into its own as a remarkably strong and useful material, apt to survive as long as canvas does in sail-boats.

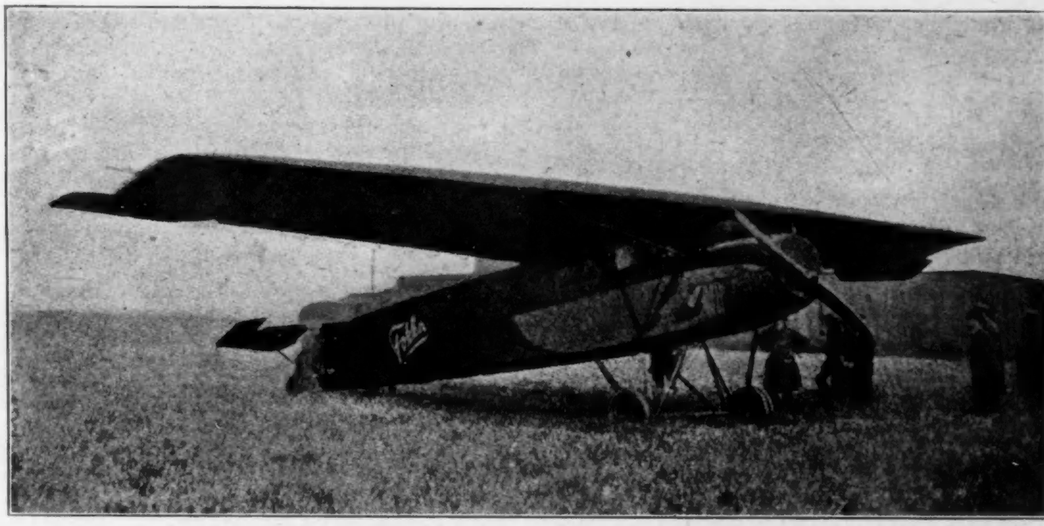
What is actually needed in the development of construction details is merely intelligent simplification of parts. This refinement is obtained only by patient effort year after year in improvements. I ran across a 1908 type of airplane recently. When I saw the hundreds of different little fittings, gadgets and turnbuckles, no two of which were alike, innumerable different sizes of wires, etc., I had a very keen appreciation of how greatly airplane construction has advanced.

Influence of War Aviation

One hears much about the great number of years of progress the four years of war contributed to aviation. Such statements are surely made without a sincere study of the subject. . In my opinion, war aviation hindered the development of commercial aviation for just that particular period and did still greater harm. It caused thousands of our young men to think of aviation in the terms of the battle front, where the disagreeable features of air fighting and that particular type of professional use of the airplane gave them an entirely different viewpoint than is needed for the stimulation of the use of the airplane as a pleasure vehicle. I know dozens of former war pilots who see no future advantage in flying. They cannot see that commercial peace-time flying will be entirely different.

During the war the details of construction that developed in simplification would, I believe, have developed more rapidly and with a more direct bearing upon commercial aviation, had there not been that tremendous military urgency, making it necessary for designers to compromise in innumerable instances upon the ready at hand 50 per cent correct detail, which would work well enough, in place of the ideal which they would have sought had they not been pressed for quick results by the greater emergency. For example, the simplest detail in an airplane is the seat; but in war airplanes today there is no really comfortable seat and certainly nothing that has had put into it the thought that has been put into seats in automobiles. From a war-airplane standpoint this is correct. From a peace-time standpoint the ignoring of such details is obviously wrong.

Since the war there has been great progress in working out some of these details required for the commercially successful airplanes. A survey of the progress that has been made in the last two years shows where we

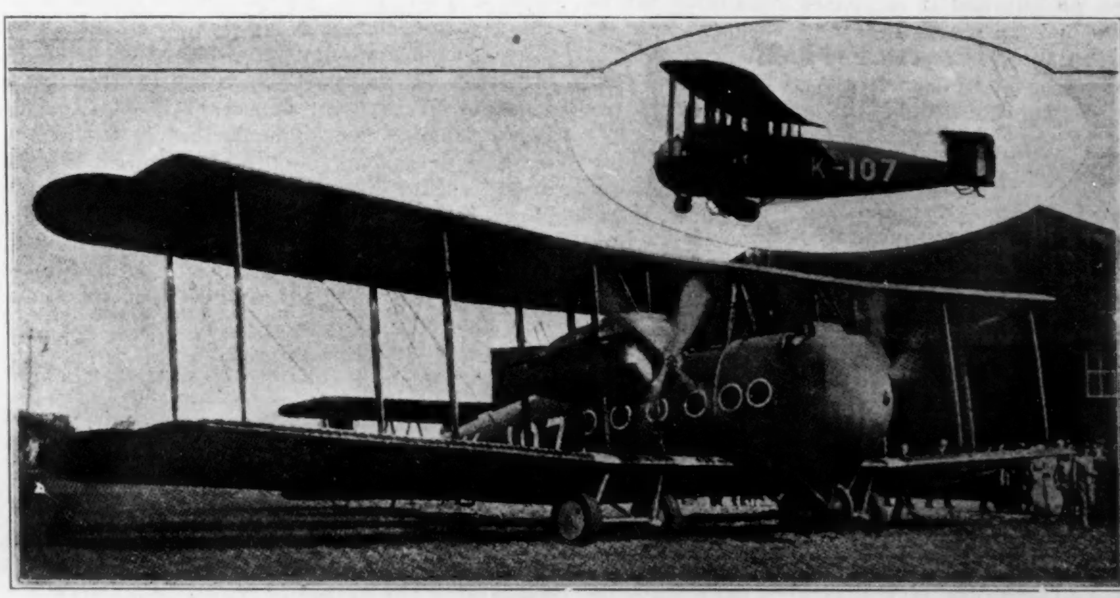


THREE-QUARTER FRONT VIEW OF THE FOKKER PLANE

would have been three or four years ago in commercial aviation had we not devoted our energies to the military side. It is unfortunate if, as maintained here, with all the money spent during the war commercial aviation was not greatly benefited; but a review of the conditions serves to bring out some of the distinctions between military and commercial aviation more clearly.

One of the results of the feverish influence of the enormous aviation activity during the war was to start a commercial aviation campaign of overselling, which threatened to wreck the whole industry. Because thousands of airplanes had flown over the battle front, of course it followed, in the minds of many people, that thousands of airplanes would immediately fly over the cities. The expected result failed to materialize, whereupon aviation was pronounced impractical by many. As a matter of fact, between these two extremes the really sound use of airplanes here and there in an entirely practical way that is possible and would, if followed, lead to a thoroughly solid, conservative development, was rather swamped in the rest of the noise. As a corollary of this state of affairs, many attempts at great flying demonstrations were carried out over bad country and, therefore, accompanied by serious accidents. A year of this, in which the number of fatal accidents was great, is taking years of patient effort to efface and, as stimulating public interest and helping the aviation business, it was devoid of helpful results. In other words, it would be far better for the aviation industry to go all the way to the other extreme and never fly unless a safe performance were absolutely certain.

How beneficial such policy can be was shown by the change in the plans for the Pulitzer race. It was originally intended to fly across the continent, in a manner that would not have permitted proper organization of flying fields for safety, and presumably would have resulted in many serious crashes. Instead, it was very wisely decided by the Aero Club of America to hold the race over a short circuit of flying fields situated on Long Island, an ideal flying race-course. The result was that, with about a dozen machines coming down in forced landings, there was not a single serious accident. The reason was that practically all of these machines landed on flying fields, or on fields that permitted of reasonably safe landing. There was a very wide-spread realization, on the part of a vast multitude of people who had seen



THE VICKERS-VIMY COMMERCIAL AIRPLANE

the race, of the fact that after all aviation is not so dangerous, and this was expressed in editorials in papers throughout the country. The dangers were exactly the same as in any other race, but disaster was not courted as it had been theretofore.

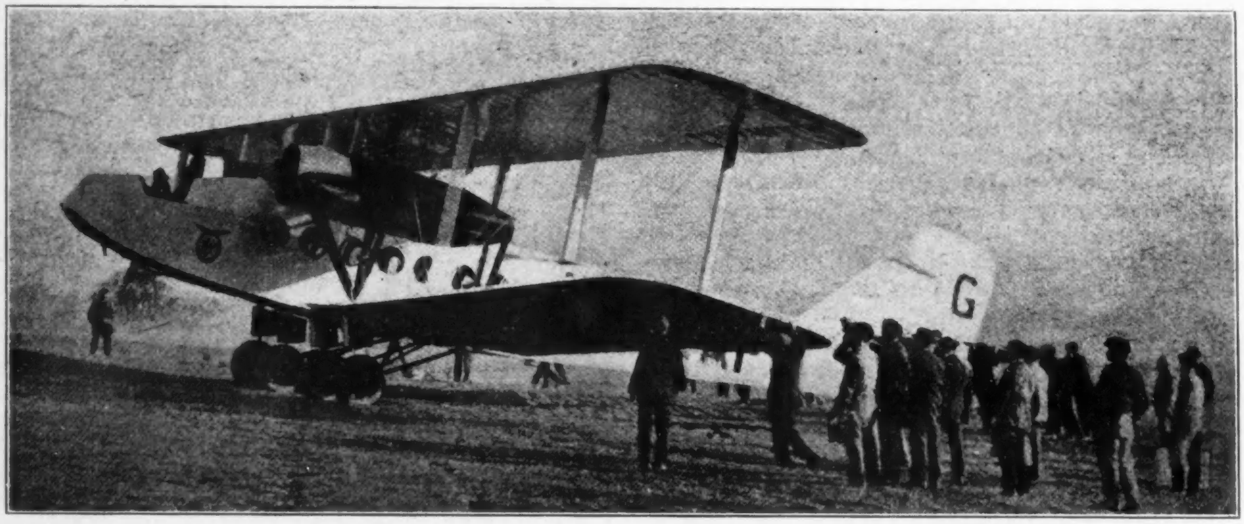
Questionable Future Developments

The future developments spoken of at present which possibly are apt further to mislead commercial aviation can be considered briefly.

(1) Are the higher-powered engines, that many are interested in, being developed along the right lines
(2) Is the introduction of complications, such as variable camber and retractable running-gear, really necessary
(3) Are the new "high-lift" wings so important
(4) Is an "aerial tramp" desirable

Commercial experience to date seems to indicate that higher power is not needed as much as greater reliability. The loads on commercial machines are becoming so high in proportion to the weight of the engine that the advantage of the retractable feature will become almost negligible. In other words, is it not likely that simplicity and refinement of what we have will give a neater landing-gear of fewer parts and perhaps less weight, as against taking our present clumsy landing-gear, admitting its clumsiness to be unavoidable, and adding the complication of hoisting it into the body? For a small racing machine the landing-gear saving is of much higher proportionate value, due to the small size and weight of the airplane.

Concerning the new "high-lift" wings, we hear much today about various wings guaranteed to give enormous lift, the statements being accompanied as usual by prediction that our old friend the "problem" has been solved. In none of the data presented on these high-lift wings, such as those for the Handley-Page, are any figures given as to the increased weight of the airplane, due to the much greater weight of the wing structure, which will very likely be found necessary to make these new types of wing as strong mechanically as the present ones and capable of being operated in the air. I venture to predict that 50 per cent or more of the increased lift claimed will be used up in the load added to the dead-weight of the airplane, due to a heavier structure. Certainly, one thing must be admitted; any such complicated construction will be more expensive and require more maintenance. Here again we see a false lead, perhaps swamping a sensible development, that is to take our present wing structure and modify the curves themselves so as to get a high-lift wing-section. This is being done already by many constructors, and incidentally in many cases with marked success. It still appears possible to modify the curve of the rib and gradually improve the depth of the wing for ample spar room, without any serious increase in the resistance and yet with a higher and higher value to the lifting coefficient. Development in this way will follow closely the same trend as the development of the lines of hulls of boats followed, resulting in gradually decreasing their resistance per horsepower for a given buoyancy.

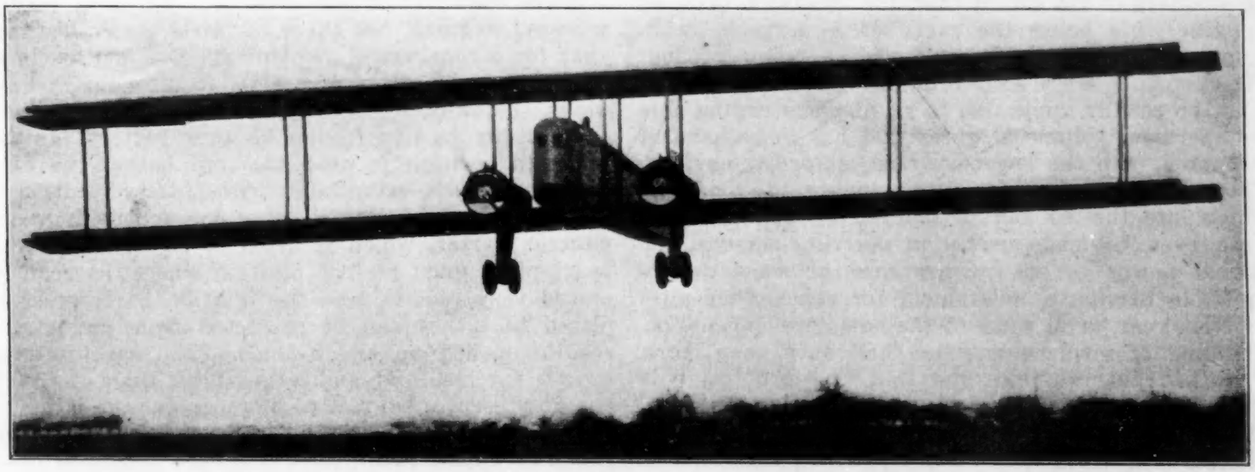


The Handley-Page W8 Airplane Propelled by Two Napier Engines

that 100 lb. more or less is not a serious difference and can very well be afforded if increased reliability can be obtained thereby. It seems that new ideas in engines are not as requisite as consistent perfection in the details of what we have, I mean details of installation that are admittedly bad and could be made better if the engine were simpler to install.

A slight increase in speed is obtainable by drawing the running gear up into the body and by flattening out the camber, but a point to bear in mind is that variable camber does not give higher lift than a "high-lift" wing-section. The point is difficult of argument in the abstract. The innovation is undoubtedly worth trying but, as in the case of many other things on airplanes, to justify itself the complication will have to show far greater advantage than it seems it will show. It is not likely that with the engines available commercial airplanes will run much over 120 m.p.h.; so, let us examine a landing-gear representing a total head resistance of approximately 57 lb. at this speed on a 5000-lb. airplane of 400 hp. Without any increase in weight, the retractable feature would reduce the head resistance by this amount and cause the machine to speed up 2.3 m.p.h. But if the head-resistance of the landing-gear itself is halved by modified and more careful design, it is obvious

By "aerial tramp" is meant a slow load-carrier. It is almost certain that airplanes will be load-carriers. But, will they be slow? The whole idea of using them to carry loads is to exceed the speed of a train or boat; warranting the higher expense. We should look forward to the time when high-class express and passenger traffic



The Farman Goliath Airplane

will be carried by air, with the railroads devoting themselves to the heavy freight about which there is no great hurry. The competition in load-carrying can be expected to be keen, particularly when it is realized how long cheap freight haulage has maintained its volume of business against the express. Apparently there is a minimum load for a commercial airplane; namely, eight or ten passengers, or 1000 to 2000 lb. of goods. Since the entire object of commercial aviation is to provide transportation at high speed, is it not likely that the development will be along the lines of carrying this load at higher and higher speed, rather than more and more load at the same speed?

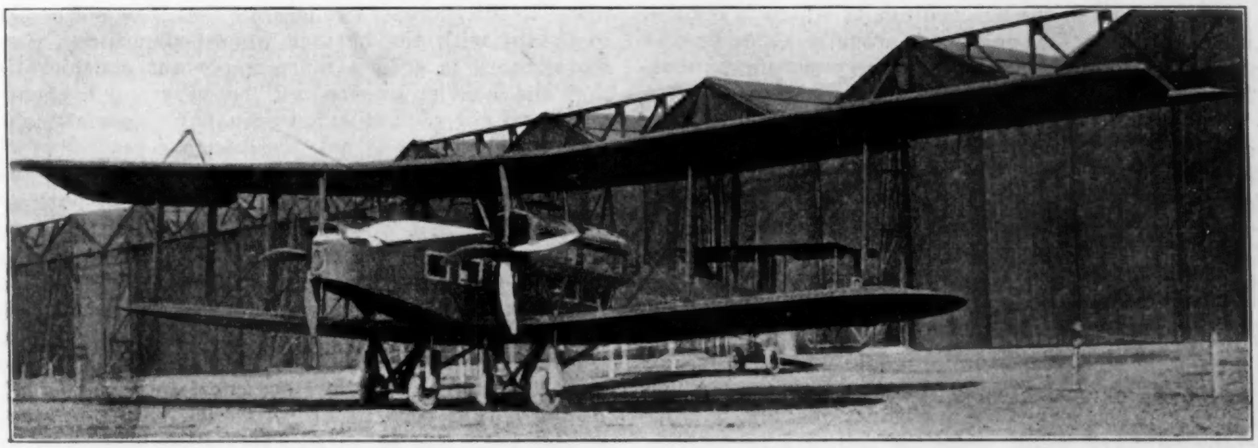
Desirable Future Developments

Among the modifications to airplanes that can be looked forward to as highly desirable and much needed for the advancement of commercial aviation is durability of construction. In this should be included the reliability of operation of the engine as the foremost necessity. Mention has already been made of the fact that increased durability of the structure of the airplane itself, is apparently obtainable by simplification when wood is used, and by the use of steel tubing in the fuselage and other parts such as the control surfaces and landing-gear. In the wooden construction there must be eliminated the fussy glued-up parts, tacked together with pieces of veneer which, when they soak up water, begin so readily to open seams, or when stored for a long time not only warp but in many instances because of the peculiar glue used start a deteriorating sort of fungus growth. A good healthy piece of wood will last as long on an airplane as on a boat and, taken hold of by a simple and accessible metal fitting, can be expected to give ample durability. Then, too, in the interest of durability, airplanes should receive some care. Is it too much, for example, to ask that they receive the same care as yachts or high-class motor cars receive? It is shocking to see the condition of some commercially used airplanes; one marvels not at their lack of durability but that they can be flown. As long as the delicate part of the airplane, the engine, needs the attention which it certainly must have, it is not a difficult matter to clean and polish the structural parts of a machine. Our present construction, therefore, with a little more steel framing used, with the wooden parts few in number and made large and solid, and, above all, with the construction accessible for inspection and cleaning, appears to offer plenty of durability for commercial purposes.

There are many desirable features to be looked for in the development of the powerplant; for example

(1) Muffling devices to deaden the noise of the engine
(2) Gearing, or geared-down engines or, better still, slower running engines to improve the propeller horsepower by increased efficiency, particularly at getting-off speeds and climbing speeds
(3) Further development of the reversible-pitch propeller
(4) Finally, the development of what now seems to be an ideal airplane engine

The necessity of mufflers need hardly be dwelt upon, because there is nothing more disagreeable or that robs



The Handley-Page 0-400, a War Type of Airplane Which Has Been Modified for Air Transport

flying of more of its charm than the incessant noise of the engine, this being the cause of a nervous strain that unconsciously makes people dislike flying without exactly knowing why. An ordinary motor-car muffler may not be readily applicable to an airplane engine, due to the enormous volume of gases that has to be handled as compared with the lower-powered motor-car engines, but the exhaust of an engine has an energy, the firing off of which into the air can be delayed by many means, and can even be made useful in deriving some slight additional power or, as in the case of some superchargers, in driving a mechanism for some other purpose. Next year, after some of the new developments on the muffling of airplane engines shall have been more fully worked out, we may find that this problem will have been solved in an efficient manner involving relatively little weight.

The use of gearing is a difficult matter; that is, the gears must be pretty tough to stand it. The big problem appears to be the heat transfer. The loss of power in the gears is represented largely by heat. In the high-powered engines this means that an enormous quantity of heat must be taken away from the gears. Various oil-cooling devices have been experimented with. Some of them work, but the weight of the gearing is still high, ranging from 1 to 1½ lb. per hp. A detail like this, however, can be developed only by persistent hard work in eliminating defects. Many people are working with this in view, particularly in Europe. The ultimate aim is, of course, to derive an airplane with an engine-room such as one has on a boat, with the engine accessible at all times and permitting minor repairs during the flight. It is not easy to state whether gearing justifies itself, for the simple reason that really successful gearing has yet to be developed.

The reversible-pitch propeller will probably make it possible to land an 80 m.p.h. landing speed airplane in the space where a 40 m.p.h. machine lands today. Conversely, due to the variation in pitch available, there is a higher thrust at slower air speeds thus offering more power for acceleration and therefore giving a quicker get-away and climb for getting out of small fields with a fast machine. It is very convincing to see an airplane with a reversible-pitch propeller come down for landing in a normal manner and, just after wheels make contact with the ground, when the long roll to the other side of the field begins, observe the reversible-pitch propeller come into play and slow the machine up quickly.

To put down in specifications what would be an ideal aviation engine for commercial purposes is almost impossible in the present state of the art. We have an S. A. E. committee in the proceedings of which it is ruled that if two aeronautical engineers actually agree on any one point, the verdict concerning it becomes unanimous. In other words, every designer seems to have his own favorite hobby. Some features, however, can be stated as covered by considerable agreement among constructors and operators of airplanes. For example, the simplest smoothest-running engine is a six-cylinder vertical. It is narrow and has comparatively low head-resistance and its length is not serious in a commercial machine. It is simple and accessible. But the trouble with our present six-cylinder types of engine is that they are either too low-powered or operate at too high a speed. If the airplane designer could have a 300-hp. engine turning at 1000 to 1200 r.p.m. he would have not only a higher propeller efficiency without gearing, but the slower engine speed would make the use of a reversible-pitch mechanism easier and the propeller less noisy.

Some constructors are greatly in favor of very high-powered engines, but there is fairly general agreement that for a commercial airplane at least 300 hp. is necessary. The advantages of gravity feed for the fuel are obvious, so the ideal engine must have its carbureter low, facilitating gravity feed. Whether battery ignition or magneto ignition is used does not bother the airplane man very much, except that with battery ignition it apparently becomes slightly more economical to install an electric starter, which is much to be desired. But the spark-plugs must be in a position where they can be removed very readily, and the ignition parts must be so placed that they can be protected from dampness and readily opened up and cleaned. The carbureter must have a far healthier and larger filter than any of them has at present. No matter how careful one is with fuel lines, there is always the possibility of dirt getting down to the carbureter, with the consequent danger of clogging the needle-valve. The ideal airplane engine for commercial purposes should also carry its oil and all the connections that have to do with it in the engine, and have incorporated in its design a centrifugal oil-cleaner.

The engine, as already pointed out, must be equipped with mufflers. Furthermore, when we consider the radiation system, which has been a bete-noir by actual statistics, on over 85 per cent of the airplane types developed to date, we find incompetent work on the part of airplane and engine people alike. The fact of the matter is that many of the faulty radiation systems that exist are faulty only because they have really never been tested properly. The engines are run through their endurance test of 50 hr., but with a water barrel holding perhaps 25 gal. of water, many feet above the top of the engine, giving a condition of circulation in the engine that is not at all similar to that of the airplane's system. When 50-hr. tests are made on a powerplant in the future they should be made on a complete powerplant, in which the radiation system, as actually intended to be used, is considered fully as important as any other item. As a matter of fact, there is considerable question as to where the design of the radiator and its connections should be left to the airplane constructor to work out.

Given an engine of the above characteristics with its six big cylinders, the airplane designer can afford to offer to use this engine with considerable enthusiasm, even if its weight for 300 hp. is as high as 1400 lb., or twice the weight of present 300-hp. engines. With an engine of this weight it would be possible to fly a 5000-lb. airplane at well over 100 m. p. h., carrying at least 1500 lb. of useful load. The sacrifice of a passenger or two, due to the heavier weight of the engine, is a minor matter compared to the increased reliability that it would be possible to obtain with the heavier weight-allowance. Furthermore, there is even a more important consideration in that the heavier engine will be very much cheaper to build and not require extraordinarily fine materials.

In conclusion, is it not possible in a resume of design characteristics and requirements for commercial aviation to place many developments in their proper category by emphasizing that all-metal construction is a secondary need, a gradual development in itself already resulting in partially metal construction; that in structural features what is needed is great simplicity and refinement in the reduction of the number of parts and fittings, whereas in the engine and installation we have simply to go along our present lines a little more consistently and patiently to obtain that element of reliability which is more important than any other element in connection with airplane construction.

The Volatility of Internal-Combustion Engine Gasoline

By Frank A. Howard[1]

Annual Meeting Paper

Illustrated with Drawing

THE meaning of the term "gasoline" seems to be generally misunderstood for the reason that it is assumed that gasoline is, or ought to be, the name of a specific product. It is not and never has been a specific product; whether it can be, or should be, I shall leave to your judgment.

Gasoline has a definite and fixed generic meaning in the oil trade, but no specific meaning whatever. It means merely a light distillate from crude petroleum. Its degree of lightness, from what petroleum it is distilled and how it is distilled or refined are unspecified. It may not be known generally that practically every grade of distillate which was ever popularly known as gasoline is still made and sold. It is not sold as gasoline, but is distributed under its specific trade or technical name, such as "76 naphtha," "66 naphtha," "P C naphtha," or something else. Such sales are only at wholesale or on a contract basis as a rule, not through the retail bulk distribution systems for engine fuel. No product of the nature of gasoline can be economically distributed at retail in bulk unless there is a large and constant demand. This is our clue to the only specific meaning of the word gasoline. Specifically, "gasoline" is the particular grade of gasoline which at a given moment is distributed in bulk at retail. I think it can be defined with reasonable precision as being the cheapest petroleum product acceptable for universal use as a fuel in the prevailing type of internal-combustion engine. I emphasize the three factors of this definition: (*a*) the cheapest product, (*b*) its universal use and (*c*) the prevailing type of internal-combustion engine.

So long as there is any such thing as a single prevailing type of engine and so long as there is substantial unanimity of view as to the acceptability of any single grade of product in this engine, the definition I have given is practically an axiom. This has been the condition up to the present time, and it is in some ways an ideal one. On this point, however, I am holding no brief. My sole purpose in this discussion is to clear away, if possible, some of the haze which surrounds the word "gasoline." If I have helped to make clear the fact that gasoline in the specific sense in which it is used does not purport to be a fixed product, but only the official title of the successful bidder for popular patronage in the engine-fuel market, my purpose will have been served. Until we have a Volstead act on engine fuels, prohibiting the manufacture and sale of any hydrocarbon product containing more than ½ of 1 per cent boiling above 300 deg. fahr., unless denatured with a sufficient quantity of carbon tetrachlorid or other approved fire extinguisher to make it poisonous to any misguided engine which may attempt to use it internally, I do not see how we are to prevent some enterprising refiner from offering to the public an engine fuel different from that which has been previously sold as gasoline. If it gives more service at lower cost than the competitive products, I do not see how we are to keep the public from buying it or prevent the public from continuing to call it "gasoline" if so minded.

I shall try to tell what volatility is with reference to engine gasoline. The prevailing type of engine up to this time has been essentially a gas engine, an engine which consumed its fuel in the form of a gas. The two prime requisites of the gasoline are, therefore, that it be a fuel, and that it be capable of conversion into a gas. So far as I know, no one has yet questioned the fact that gasoline is a fuel, but there seems to be a widespread conviction that it cannot be gotten into the cylinders in the form of a gas. This low volatility of gasoline, and its volatility is low, is the root of most of the trouble which is being and will be met with. My purpose is to show how much of the difficulty is inherent in the fuel and how much of it arises from the failure of automotive engineers, collectively, to attain a high average of perfection in the handling of the fuel. This is not a criticism. Among engineers, at least, I think it safe to refer to an engine as 10 per cent or 50 per cent efficient, without the deduction being drawn that the responsible persons are being haled before the bar of public opinion for their 90 per cent or 50 per cent of shortcomings.

Ordinary engine gasoline of the grade now sold possesses sufficient inherent volatility to take and maintain the condition of a gas at a temperature at or below average intake-manifold temperatures. Manifold condensation seldom, if ever, occurs and cylinder condensation is even less probable. The phenomena answering to these names are in fact mainly the visual evidences of the failure of the vaporizing device to function. Fuel once vaporized must stay in that condition; hence, if liquid is found beyond the vaporizer, it reached there as a liquid. These conclusions are based on an examination of the fuel itself. Here is the evidence; first chemical, then physical:

Volumetric Proportions of a Combustible Mixture

As a corollary of Avogadro's law, the volumetric proportions of a mixture of gases are represented by their molecular proportions, and these in turn are represented directly, in the case of a gaseous fuel mixed with the proper amount of air for combustion, by the equation of combustion itself. For example:

$$C_5H_{12} + (8O_2 + 32N_2) = 5CO_2 + 6H_2O + 32N_2$$

From the equation it therefore appears that a perfect mixture of pentane gas, or vapor and air, must consist of 40 parts by volume of air made up of 8 parts of oxygen and 32 parts of nitrogen and 1 part by volume of pentane. Pentane is the lightest hydrocarbon found in any substantial amount in gasoline. Again:

$$C_{11}H_{24} + (17O_2 + 68N_2) = 11CO_2 + 12H_2O + 68N_2$$

This shows that a perfect mixture of vaporized un-

[1]M. S. A. E.—Development manager, Standard Oil Co. of New Jersey, New York City.

decane and air comprises 1 part of the fuel and 85 parts of air, by volume. Undecane is probably the heaviest hydrocarbon present in any substantial amount in gasoline.

Since gasoline consists of hydrocarbons lying between these limits, there being more of the lighter than of the heavier, the volumetric proportion of gasoline vapors in a perfect mixture will be somewhere in the neighborhood of 1 part in 60, or 1.67 per cent. It may help us to appreciate this if I say that the air of this room normally contains a proportion of water vapor just about this high. If water were gasoline, we would be living in a substantially perfect combustible mixture most of our lives. If we can visualize this condition, it will be easier to follow the physics of this question.

The boiling point of water at sea level, under a normal barometer, is 212 deg. fahr. Nevertheless, the air of this room contains something between 1 and 3 per cent of water vapor. How did it get here and why does it stay here? It got here by evaporation from the sea and it stays here because it cannot condense. Apparently, therefore, the boiling point of water, or of engine fuel, does not fix the temperature at which it evaporates and stays evaporated. Some other factor must be involved. This factor is the *proportion* of vapor in the air. The boiling point is the temperature at which there is 100 per cent vapor in the air, which is an Irish method of stating the fact. Since automotive engineers are interested in a perfect mixture containing less than 2 per cent of vapors of gasoline, it would appear, therefore, that the boiling point of the gasoline is more a matter of academic interest than a critical measure of its volatility. From an automotive engineering standpoint, the volatility of the gasoline is to be determined by its ability, or lack of ability, to form a stable 1 or 2 per cent mixture with air, and not by its ability to form a 100 per cent cloud of gas pushing the air away ahead of it, which is the phenomenon called boiling. If it is a light gasoline, such as pentane, we want it to be stable up to about 2 per cent; if it is heavy, like undecane, we want it to be stable up to about 1 per cent. From this we draw the interesting conclusion that the lighter the fuel is, the greater its volatility must be to permit it to exist as a stable mixture. Roughly, pentane must have twice the absolute volatility of undecane to be equally volatile from a carburetion standpoint. It actually has more than twice the absolute volatility, but the thing to be borne in mind is that a comparison of absolute volatilities will be very misleading unless read with a combustion equation which fixes the required volatility. The true comparison is the relation of absolute to required volatility of the fuels compared.

Physical Meaning and Measurement of Volatility

The physical laws which govern the volatilization or vaporization of liquids were clearly enunciated by Dalton about a century ago. These laws, or the one law and its corollaries, are generally referred to as Dalton's Laws of Vapor Tension, and can be stated adequately for the purpose of this discussion as follows:

(1) A liquid will continue to evaporate from an exposed surface thereof until there is established on that surface a definite pressure of the vapors of the liquid

(2) This definite pressure changes with the temperature of the liquid, but is independent of the presence, character or quantity of any other gases or vapors existing above the liquid

(3) This definite pressure is called the "vapor tension" or "vapor pressure" of the liquid at that temperature. If the vapors of the liquid are admixed with other vapors or gases, the total pressure of the mixture multiplied by the volumetric percentage of any constituent gives what is plainly named the "partial pressure" of that constituent. So long as this partial pressure of the vapor in question is below the vapor pressure of the liquid at that temperature, condensation cannot occur

The usual method of measuring the volatility or vapor tension of a liquid is to introduce a sealed vial of the liquid into the space above a mercuric barometer column, then to break the vial and read directly the lowering of the barometer which shows the pressure developed by the vapors of the liquid. This, of course, gives the vapor pressure in vacuo, which, according to Dalton's laws, should be the same as that developed in air or in any other gas. Generally this is true, but in the case of gasoline and some other mixed liquids the results obtained differ slightly from measurements made in air. Since we are directly interested in the vapor tension in an atmosphere of air, the form of instrument designed by C. I. Robinson, chief chemist of the Standard Oil Co. of New Jersey, is preferred. This instrument is illustrated in Fig. 1. It consists of a graduated U-tube *a*, one leg of which is surmounted by an air bulb *b* cut off by cocks. The upper one is a two-way cock and this, in turn, is surmounted by a feed reservoir and trap *c*. In using this instrument, both legs of the tube, as well as the reservoir and the trap, are filled with liquid to be measured, leaving the cut-off bulb filled with air. The two legs of the tube are balanced. Liquid is then permitted to drop through the bulb for a few minutes. The upper cock is closed, the legs are balanced again and the increase in the volume of air is read directly on the graduated leg of the tube. The temperature is controlled by immersing the whole instrument in a water bath before and during the measuring.

With this instrument, the absolute volatility of an average 58-deg. Baumé engine gasoline of the present-day grade was determined as follows: First the vapor tension of the original gasoline was determined at two temperatures. Then the sample was reduced by distillation in the ordinary way, taking off successive 10 per cent fractions. After each reduction operation the vapor tension of the residual portion of the gasoline was determined at temperatures of 50, 75, 100 and 125 deg. fahr. Table 1 gives a complete inspection of the original gasoline and Table 2 shows the results of these measurements.

In dealing with a complex liquid such as gasoline, the full interpretation of these results carries us much further into the field of the physical chemist than it is necessary for us to go today. We are dealing specifically with the question of minimum volatility. Is gasoline inherently volatile enough to permit complete vaporization at ordinary manifold temperatures or is it not? Let us, therefore, take the heaviest portion of the gasoline, the last 10 per cent, which we find has a boiling-point range of 380 to 435 deg. fahr. It is this portion which some of you automotive engineers have urged the refiners to cut out, stating that it cannot possibly be vaporized or kept from condensing and is, therefore, not only of no value but actually detrimental to the engine. Returning to our combustion formula we find that if the fuel were composed entirely of this very heaviest fraction, a perfect mixture would contain about 1.2 per cent of fuel vapor. The average pressure in an engine manifold is around 0.5 atmosphere. Calling it 400 mm. of mercury, $0.012 \times 400 = 4.8$ mm.; which is, therefore, the partial

TABLE 1—57.9-DEG. BAUMÉ ENGINE GASOLINE USED FOR VAPOR TENSIONS

Temperature, deg. fahr.	Percentage Off
Start 108	..
122	2
140	4
158	8
176	12
194	17
212	23
221	26
230	29
248	36
266	43
275	47
284	51
302	60
320	68
338	75
356	83
374	88
392	92
410	94
428	96
Final 435	97 Recovered

pressure of fuel vapors, assuming that we have a fuel made up entirely of the least volatile fraction of the present gasoline. We find that at any temperature above 125 deg. fahr. the least volatile portion of the gasoline has a vapor pressure well above 4.8 mm. Our conclusion must be, therefore, that even if the gasoline consisted entirely of what is at present its heaviest constituent, it would still possess sufficient inherent volatility to make it a possible fuel for an engine essentially a gas engine. It is a fuel and can become and must remain a gas at an intake temperature not substantially higher than present practice.

This examination of the volatility of a typical engine gasoline does not represent the whole of the problem by any means, but it does indicate what is possible and what is impossible. Stating it generally, complete vaporization of fuels much less volatile than those now sold is possible without increase of mixture temperatures; condensation of these fuels is impossible. Let us first dispose of the last statement. Manifold condensation is impossible, above the temperature indicated, because it is physically impossible for any vapor to condense when its partial pressure is lower than the determined vapor pressure of the liquid itself at that temperature. This is apparently the average condition in an engine manifold. So far as I know, there is no malicious mechanical magnetism in a gas engine which suspends the operation of the laws of nature. So-called "condensation," in most cases at least, must therefore be the mere separation of liquid which was never vaporized. Precisely there lies the difficulty. Vaporization is possible, and without higher manifold temperatures; but it is difficult to obtain.

TABLE 2—VAPOR TENSIONS IN MM. OF MERCURY AT VARIOUS TEMPERATURES

Temperature, deg. fahr	50	75	100	125	Specific Gravity, Bottoms
Original Gasoline	121.80	180.05	......	......	......
Residuum, per cent					
90	44.75	69.51	115.20	156.35	54.6
80	17.45	31.18	54.92	103.20	52.9
70	16.65	24.65	41.49	69.75	51.3
60	9.66	14.35	24.59	45.82	49.8
50	8.45	13.35	18.41	29.50	48.4
40	4.84	8.08	11.32	17.50	46.2
30	....	6.75	8.48	12.55	45.3
20	....	....	1.64	8.05	43.1
10	....	....	....	5.07	40.1

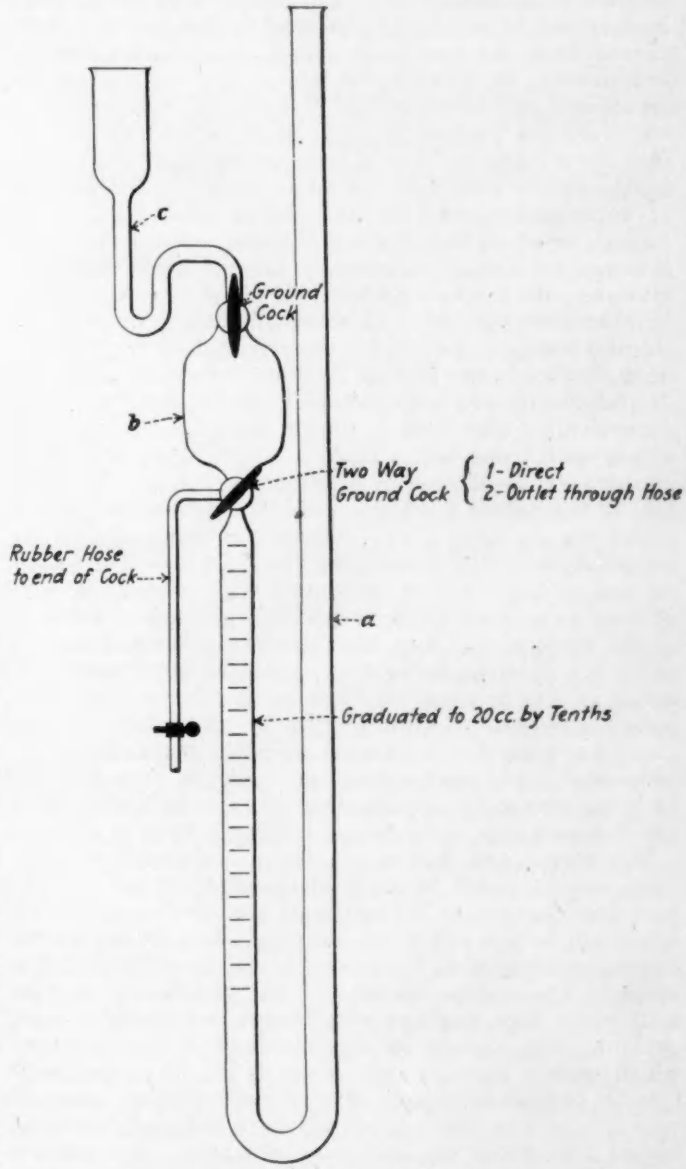


FIG. 1—SPECIAL APPARATUS DEVELOPED TO DETERMINE THE VAPOR TENSION OF GASOLINE

REQUIREMENTS FOR FULL UTILIZATION OF INHERENT VOLATILITY

The utilization of the full inherent volatility of the fuel is dependent upon just three things, time, surface and heat. The relation can be expressed mathematically as follows:

$$\text{Vaporization} = \text{Time} \times \text{Surface} \times \text{Heat}.$$

If the time element is large, surface and heat may be infinitely low. If surface is infinitely large, the other two may be infinitely small. If heat is applied rapidly enough and at a high enough potential or temperature, surface and time become unimportant.

So far as I know, no way is promised yet for bettering

the time factor. The other two, however, automotive engineers are bettering daily in several ways. Air heating and manifold heating are helpful, but apparently the means which best meets the physical requirements of volatilization is the so-called hot-spot. The definite problem is to supply heat to the fuel; not to supply heat to the air or to the mixture, but to the fuel itself. This heat should be supplied to the fuel in the presence of the air to have its maximum effect. The latent heat of evaporation of gasoline is about 130 B.t.u. per lb.; its specific heat is about 0.5. Even if we wished to do so, we could not preheat it very much before introduction into the airstream, because such preheating would distill off the lighter fractions and waste them. The latent heat of vaporization must be and should be applied to the fuel as, or after, the mixture is made. One obvious way is to preheat the air; another, to directly heat the charge. However, the heat conductivity of air is so low that, unless these are carried to an extreme which results in substantial loss of power, there is not sufficient time for the necessary exchange of heat between the evaporating fuel droplet or film and the enveloping air current. It can be demonstrated that even in highly heated air a fuel drop of any great size will actually cool off rather than heat up, because the absorption of latent heat in the volatilization of the lighter fractions more than offsets the gain of heat from the air. It can therefore be expected that the temperature of the vaporizing fuel particles themselves, instead of being raised by contact with heated air, may actually be lowered as the evaporation proceeds. From all of the work in our own laboratories on the evaporation of liquids, it seems to me very doubtful whether air heating is of any measurable direct benefit in securing complete evaporation of the fuel. Its indirect benefit is very clear, however, for the heated air heats the walls of the carbureter and intake manifold and, in this indirect fashion, transmits heat to that unvaporized portion of the charge which separates as a film on these walls.

The direct and logical attack on the problem, however, would appear to be to endeavor to throw the unvaporized fuel particles positively out of the insulating airstream, which effectively prevents them from picking up very much heat in their brief travel from the throttle-valve to the engine valves. If the separating surface upon which they impinge were heated to some high temperature, the higher the better, short of the point at which carbon deposits take place, it would be perfectly feasible to take advantage of practically the full inherent volatility of the fuel. It should be noted that a highly heated separating surface upon which the unvaporized fuel particles impinge does not mean a high manifold temperature. The same insulating property of the air which makes vaporization so difficult to obtain in an old-type manifold also makes it possible to heat a separating surface of limited area on the manifold, such as a hot-spot, to a very high temperature without unduly raising the mixture temperature. I hope I have convinced those automotive engineers who may have held a contrary opinion that, so far as the mixture temperature itself is concerned, it is already high enough and that they need not fear condensation, even with fuels much less volatile than those now common.

Apparently the problem which automotive engineers face resolves itself into the further development, improvement and wider use of the hot-spot. I feel that the progress of automotive engineers in this respect has been phenomenal up to the present time. I noticed recently in one of the periodicals an editorial describing a test of a simple form of attachment hot-spot which presumably could be applied to any engine. The test showed that within 36 sec. after the exhaust gases were admitted to the jacket of the hot-spot, the mixture passing the same was perfectly dry as shown by a glass manifold. I once conducted some rather crude tests on a hot-spot of this same design and found that complete vaporization of the fuel was secured in this way with a manifold temperature beyond the hot-spot of 125 deg. fahr. The surface of the hot-spot itself at that time showed a temperature of 350 deg. fahr., as accurately as it could be measured. It is, therefore, apparent that advanced hot-spot design has already reached a point at which automotive engineers can come very close to utilizing the full inherent volatility of the fuel by the simple and logical expedient of directly heating the unvaporized fuel in contact with the air, rather than by trying to preheat the fuel or to heat the fuel by contact with heated air.

It is my hope that some data will have been found in this paper on the physical and chemical properties of internal-combustion engine fuel, from this standpoint of volatility, which will make it easier for automotive engineers to analyze properly the difficulties which they are meeting, and to understand just why and how their most promising mechanical solution of these difficulties operates. This simple solution is not only capable of being incorporated in new designs, but promises to lend itself to attachment to existing engines without great difficulty or expense. Insofar as this proves feasible, we shall apparently be able to perpetuate the mutually advantageous condition of the past, the condition of a single prevailing type of engine in which a single grade of fuel, the cheapest grade, can be used with universal satisfaction.

CORRECT ADDRESSES OF THE MEMBERS

A FORCE is maintained in the offices of the Society at New York City whose sole duty is to keep the addresses of the members uptodate. Approximately 200 changes of addresses are received each week by this department, and these are made promptly. In numerous cases the only notification which the Society has of a change of a member's address is a letter stating that THE JOURNAL, or some other communication, was delayed in delivery or was not received at all. It is of course impossible for the office to have a correct list of addresses unless the members send in such changes promptly. All members who are receiving mail addressed improperly are urged to send their correct address to the office.

A list of the members for which the Society has no correct address is given below. Communications sent to the last known business connection or mail address as it appears on the records have been returned to the New York office. Any one who can supply information regarding the present location of these members or offer any suggestions as to where their correct addresses can be obtained will confer a favor upon the Society by communicating with the Secretary at the New York office. It is only by the cooperation of the entire membership that a correct mailing list can be maintained and the members receive THE JOURNAL and other communications promptly.

BARKER, GEORGE R.
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GREEN, L. P.
HARDING, HERBERT P.
JOHNSON, A.
LEWIS, WILL I.
MCMILLAN, HORATIO G.
MILLER, JAMES A.
THEISEN, ALEXANDER J.
TUCKER, GORDON E.
WINTER, H. L.

High-Temperature Properties of White-Metal Bearing Alloys

By John R. Freeman, Jr.,[1] and R. W. Woodward[2] *Illustrated with* Photographs and Drawings

THE mechanical properties of white-metal bearing alloys have been the subject of several investigations, with the particular object of establishing the relations between the properties obtained in laboratory tests and the ultimate test of service. Practically all of these tests reported in the literature on white-metal bearing alloys were conducted at room temperature, the Brinell hardness[3] alone having been determined for a few alloys under other conditions of temperature. While we therefore have considerable knowledge of the mechanical properties of these alloys at ordinary temperatures, our knowledge of their properties at elevated temperatures is very limited. The importance of knowing the properties of bearing alloys at elevated temperatures is readily appreciated when one considers that the oil temperature in the crankcase of an automobile engine may often reach 60 deg. cent. (140 deg. fahr.) and bearing temperature of 100 deg. cent. (212 deg. fahr.) and higher have been measured in similar engines. It is the purpose of this paper to present the design of new apparatus and the results of tests to determine the mechanical properties in compression and the Brinell hardness of some representative white-metal bearing alloys at elevated temperatures.

The Non-Ferrous Metals Division of the Standards Committee of the Society of Automotive Engineers is proposing as standard white-metal bearing alloys the four compositions given in Table I.

These four alloys and alloy No. 2 of the American Society for Testing Materials[4] were selected as of representative composition suitable for this investigation. The results of a chemical analysis of the five alloys studied are given in Table 2. It will be noticed that alloy No. 2 of the American Society for Testing Materials, given in Table 2, is very similar to alloy No. 11, of the Society of Automotive Engineers, given in Table I. The properties of these two alloys are compared because the former alloy was considered by the committee of the Society of Automotive Engineers as being somewhat too hard.

Table 1—Specification for White-Metal Bearing Alloys Proposed by the Society of Automotive Engineers

S. A. E. No.	Per Cent			
	10	11	12	13
Tin	90 to 92	86 to 89	Remainder	4.50 to 5.50
Copper	4 to 5	5 to 6.50	2.25 to 3.75	Less than 0.50
Antimony	4 to 5	6 to 7.50	9.50 to 11.50	9.25 to 10.75
Lead	Less than 0.35	Less than 0.35	24 to 26	84 to 86

Preparation of Alloys

Pure Banka tin and the best grade of Star antimony were used. These metals and the copper were not analyzed, as the freedom of the alloys from impurities is proof of the purity of the metals used. An analysis of the commercially pure lead used showed lead, 99.94 per cent; copper, 0.03 per cent and antimony, 0.03 per cent.

Alloys Nos. 1, 2, 3 and 4, were prepared by first melting the tin in a plumbago crucible in a gas furnace. The requisite amounts of a 50 per cent tin, 50 per cent copper hardener and metallic antimony were then added. After the addition of the alloying elements, the temperature of the bath was carried up to the melting point of antimony and stirred to insure a homogeneous alloy. The temperature of melting was then allowed to drop to about 500 deg. cent. (932 deg. Fahr.) with continual stirring of the metal, which was then poured into a cast-iron mold. The surface of the bath was always kept covered with charcoal to prevent excessive oxidation. The temperature was measured by a specially calibrated chromelalumel thermocouple connected to a Leeds and Northrup portable potentiometer. The lead-base alloy No. 5 was similarly prepared but in this case the lead was first melted and then the metallic tin and antimony were added. The al-

[1]Assistant physicist, Bureau of Standards, Washington.
[2]Associate physicist, Bureau of Standards, Washington.
[3]Babbitt and Babbitted Bearings, by Jesse L. Jones, *Transactions, American Institute of Mining and Metallurgical Engineers*, 1919, vol. 60, p. 458.
[4]Tentative Specifications for White-Metal Bearing Alloys Proceedings of the American Society for Testing Materials. Vol. 19, part 1, page 469.

Table 2—Percentage Composition of Alloys Studied[5]

Bearing Metal No.	Society of Automotive Engineers No.	American Society for Testing Materials No.	Per Cent				
			Copper	Antimony	Tin	Lead	Iron
1	10	1	4.56	4.52	Remainder	None	Less than 0.05
2	..	2	3.51	7.57	Remainder	None	
3	11	.	5.65	6.90	Remainder	0.09	
4	12	.	2.90	10.50	Remainder	25.05	
5	13	9	....	10.03	Remainder	84.95	

[5]The authors are indebted to J. A. Scherrer of the Bureau of Standards for all chemical analyses reported.

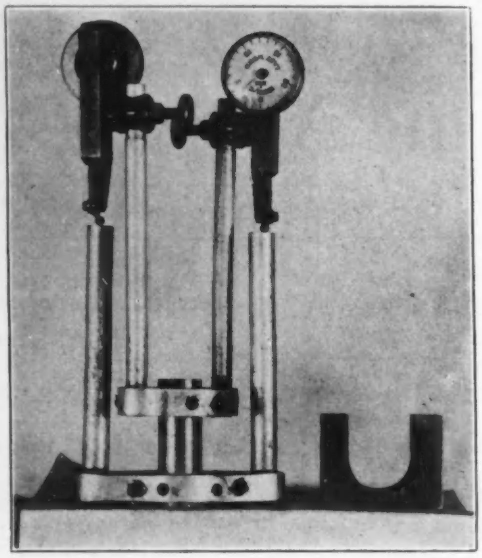


FIG. 1—THE SPECIALLY DESIGNED COMPRESSOMETER USED TO MEASURE THE DEFORMATION OF THE SPECIMENS

loys were made up to meet the mean composition of the specifications and the resultant compositions given indicate how close a desired composition can be obtained with the careful laboratory methods used.

PREPARATION OF TEST SPECIMENS

The compression test-specimens used were small cylinders 1½ in. long and about ½ in. in diameter, this ratio of length to diameter being within the limits recommended by the American Society for Testing Materials and the cross-section for these experiments being suitable for a 10,000-lb. testing machine. These specimens were turned in a lathe, with a hollow mill, from castings 2 in. long and ¾ in. in diameter which were made by pouring the metal from the desired temperature into a split steel mould of the above dimensions.

The samples for Brinell testing were similar to those used by Lynch[6], the metal being poured into an open steel mold 2 in. in diameter and ⅝ in. deep, but in this case the mold was not previously heated before pouring, always being at room temperature when the metal was first poured. Before making the impressions, the faces of the casting were turned off and the test was then made on the bottom face. Three impressions were made on each casting at equidistant points on a circle one-half the radial distance from the center. The average of these three readings was taken as the Brinell hardness under the given conditions.

APPARATUS USED FOR TESTING.

For the compression tests, the cylinders were compressed in a standard Riehle 10,000-lb. testing machine. The deformation per unit load was measured by a specially designed compressometer. A copy of a photograph of this instrument mounted on a specimen is shown in Fig. 1. The frame and uprights are made of aluminum. They are held to the specimen respectively by three small steel screws set radially in the same plane and spaced equidistantly around the specimen as shown. The small U-shaped block is a gage used for spacing the frames at the proper distance on the specimen. The distance between the plane of the screws, or the gage length, is 1 in. The Last Word dials used read to thousandths of an inch and ten thousandths can be estimated readily.

The assembly and important dimensions of the bath used for heating the specimen during tests are shown in Fig. 2, which is a section through the center. The specimen *A* is compressed between the steel posts *BB*. During tests the specimen with compressometer attached is immersed in a heated liquid; glycerine was found very satisfactory, held in the container *C*. *D* is a syphon diaphragm. This collapses like an accordion, permitting the top of the container *C* to drop below the level of the base of the specimen. This is a particularly convenient method for lowering the bath to place a specimen in position for testing, especially as it eliminates the need for any packed joints. A photograph of the entire apparatus with a specimen in position for testing is shown in Fig. 3.

The bath is heated with a small-size hot-point electric heater immersed in the glycerine. The glycerine was forced in a continuous stream over the heater by a small motor-driven propeller. This continuous stirring of the glycerine and the ready control of the heating current by a variable resistance provided an excellent control of the temperature of the specimen during the test. In all cases the temperature of the bath and, consequently, that of the specimen, did not vary by more than 2 deg. cent. (3.6 deg. fahr.) during a test.

The Brinell hardness tests were made with a standard

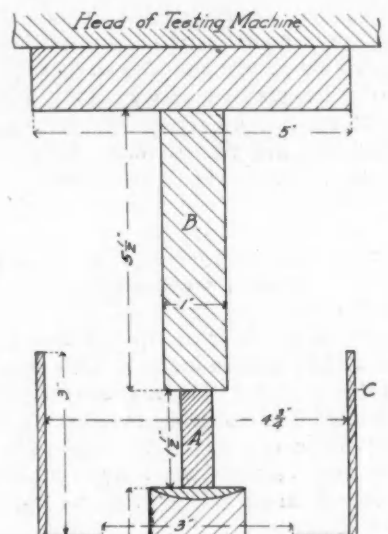


FIG. 2—SECTIONAL ELEVATION OF A PORTION OF THE TESTING MACHINE SHOWING THE ARRANGEMENT OF THE BATH EMPLOYED TO HEAT THE SPECIMEN

[6]Study of Bearing Metals and Methods of Testing, by T. D. Lynch. *Proceedings of the American Society for Testing Materials*, 1913, vol. 13, p. 699.

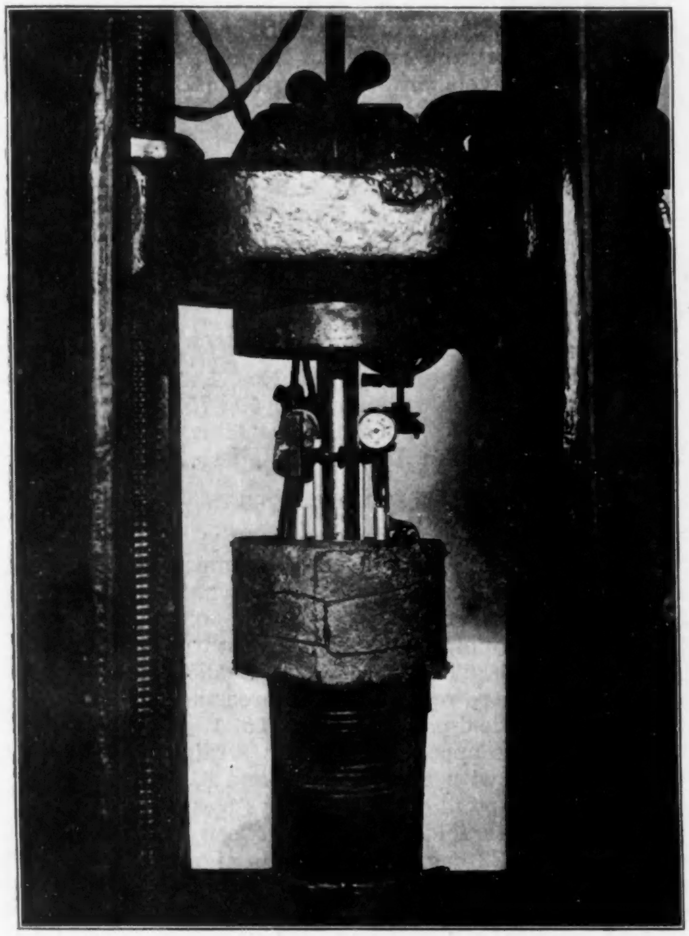


FIG. 3—THE ENTIRE TESTING APPARATUS IN PLACE

Brinell machine using a 500-kg. load on a 10-mm. ball applied for 30 sec. The apparatus shown in Fig. 4 was used for the elevated temperature tests. It is simply a suitable container for the testing liquid, glycerine, with a base made to fit on the spherical seat of the Brinell machine; and a post on the inside to support the specimen away from the bottom and permit good circulation of the liquid around it. The bath was stirred with a small motor-driven propeller and was heated by a small resistor placed in the bottom of the container. During the test the entire specimen was submerged, the Brinell ball also being completely immersed. Sufficient time was always allowed for the specimen to reach the temperature of the bath, this having been determined previously by inserting a thermocouple in a specimen and noting the elapsed time between the placing of the specimen in the bath and when the center reached the temperature of the bath.

PRELIMINARY TESTS

It is well known that the pouring temperature of a bearing metal has a marked influence on the mechanical properties, all other conditions being constant. In view of this fact, preliminary to any test at elevated temperatures the effect of pouring temperature on the compressive strength at room temperature was determined for alloys Nos. 1, 3, 4 and 5. The results obtained are given in Table 3.

In results reported in this paper the yield-point was adopted arbitrarily as being at ⅛ of 1 per cent reduction of the gage length. The ultimate strength was finally

TABLE 3—EFFECT OF POURING TEMPERATURES ON YIELD-POINT AND ULTIMATE STRENGTH

Alloy No.	Pouring Temperature		Yield-Point, lb. per sq. in.	Ultimate Strength, lb. per sq. in.
	deg. cent.	deg. fahr.		
1	400	752	3,750	12,940
	446	835	4,000	12,855
	495	923	3,500	13,500
3	390	734	3,500	15,830
	445	833	4,250	16,435
	500	932	4,000	15,830
4	300	572	5,000	14,015
	350	662	4,250	13,685
	400	752	4,750	13,635
5	300	572	3,250	13,840
	356	673	3,750	15,020
	404	759	3,250	15,245

chosen as the unit load necessary to produce a deformation of 25 per cent of the original length of the test-specimen. The reasons for selecting these values will be discussed later. After comparing the results in Table 3 and the pouring temperatures suggested in the tentative specifications of the American Society for Testing Materials, already mentioned, the temperatures given in Table 5 on page 152 were used in casting test-specimens for all further tests.

ELEVATED-TEMPERATURE COMPRESSION TESTS

Stress deformation curves were taken on all five alloys at room temperature, 20 to 30 deg. cent. (68 to 86 deg. fahr.) and at 50, 75 and 100 deg. cent. (122, 167 and 212 deg. fahr.). At least two specimens were tested

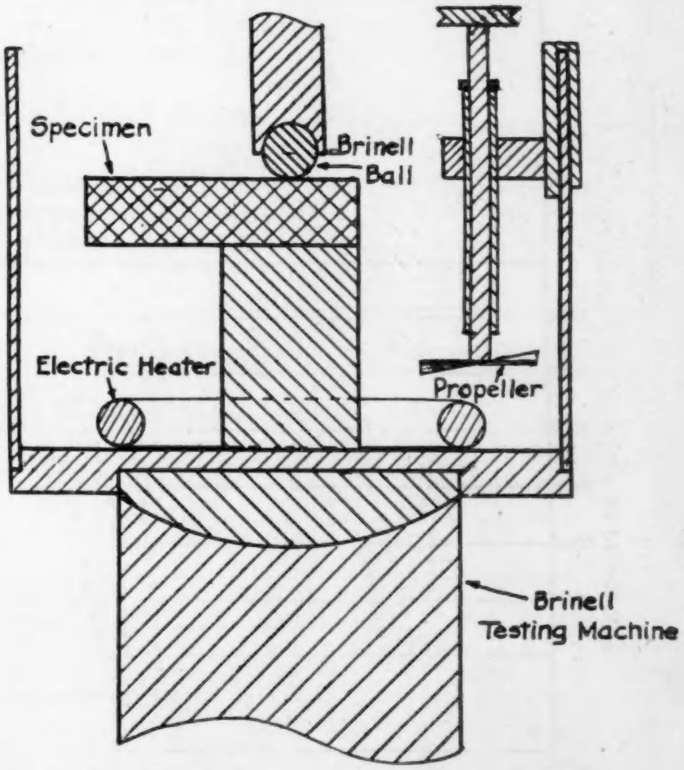


FIG. 4—APPARATUS EMPLOYED IN THE ELEVATED TEMPERATURE TESTS

TABLE 4—TEMPERATURES USED IN CASTING TEST-SPECIMENS

Specimen No.	Pouring Temperature	
	deg. cent.	deg. fahr.
1	440	824
2	440	824
3	440	824
4	345	653
5	325	617

under each condition to provide a check. Representative stress-strain curves of each alloy except No. 2, at the four temperatures, are given in Fig. 5. These show the type of stress deformation curve obtained with the apparatus described, and also show very clearly the marked change in the compressive strength of the alloys with increasing temperatures. In Fig. 5 a dial unit is equivalent to 0.00087 in. and is the algebraic mean of the total deformation shown by the individual dials for any given load.

A study of the curves shows that it is practically impossible to pick out a limit of proportionality as ordinarily determined by noting the departure of the stress deformation curve from a straight line and, further, we know that the finer the measurement is, the lower this point will be. An arbitrary yield-point was therefore determined upon. After comparing the yield-points indicated by several values of percentage reduction of gage length, the value of 1/8 of 1 per cent of the gage length, or 0.00125 in., was adopted for purposes of comparison as it generally seems to coincide with the first marked yielding of the specimens tested. This value, 0.00125 in., is practically equivalent to 1.5 division on the dial or "dial units" used in Fig. 5.

When soft metals of this type and size of test-specimen are compressed they do not eventually shear but continue to flatten out with increasing loads, so it is necessary to adopt some arbitrary values for ultimate strength which will at least be comparable among themselves. A reduction of 25 per cent of length was chosen in this investigation as at this value in all cases the load had become nearly constant for increasing deformation. In the case of high-lead alloys, the load generally reached a maximum value and then fell off before the 25-per cent reduction was reached. In these cases the maximum load was recorded. The values of yield-point and ultimate strength thus obtained are given in Table 5.

ELEVATED TEMPERATURE BRINELL TESTS

The Brinell hardness of alloys Nos. 1, 3, 4 and 5 was determined at room temperature, 50, 75 and 100 deg. cent. (77, 122, 167 and 212 deg. fahr.). The values obtained are given in Table 6.

DISCUSSION OF RESULTS

Regarding the *compression tests,* the yield-points of the four alloys are plotted against temperature in Fig. 6, for greater convenience of comparison. As one would expect from the composition, the yield-point of alloy No. 3 is considerably higher at all temperatures than that of the other alloys. The yield-point of alloy No. 3, however, falls off more rapidly, with increasing temperatures than does the yield-point of alloy No. 1. The points in both these cases appear to lie on a straight line. This is not the case with alloys Nos. 4 and 5, which contain lead. The yield-point of each of alloys Nos. 4 and 5 seems to drop off more rapidly at first, between 25 and 50 deg. cent. (77 and 122 deg. fahr.). It is significant to note that while the yield-point of alloy No. 4 is higher than that of alloy No. 1 at room temperature, it is lower at 50 deg. cent. (122 deg. fahr.) and decreases at a more rapid rate between 25 and 100 deg. cent. (77 and 212

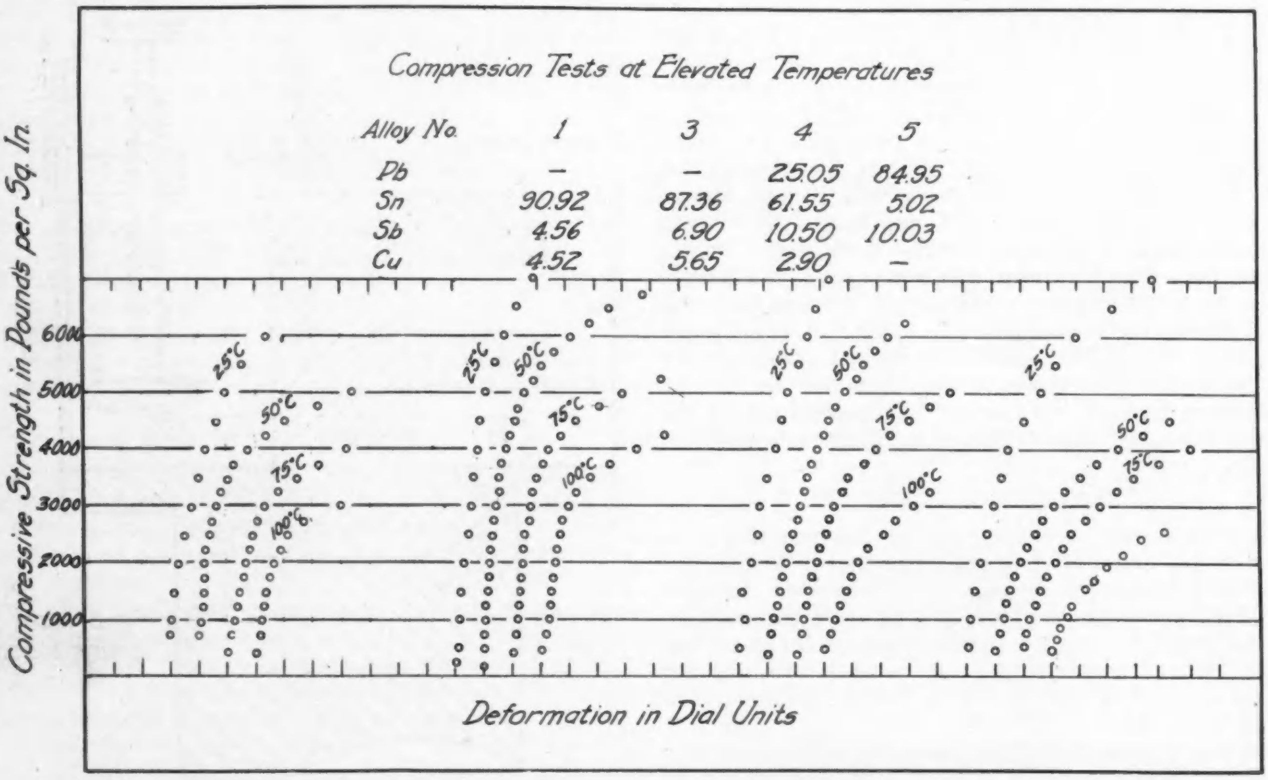


FIG. 5—STRESS-STRAIN CURVES OF THE ALLOYS AT DIFFERENT TEMPERATURES

Table 5—Yield-Point and Ultimate Strength Values

Temperature		Yield-Point, lb. per sq. in.					Ultimate Strength, lb. per sq. in.				
		Alloy No.					Alloy No.				
deg. cent.	deg. fahr.	1	2	3	4	5	1	2	3	4	5
25	77	4,400	6,250	5,750	4,700	3,750	12,850	15,175	16,425	13,685	15,020
50	122	3,800	4,850	5,000	3,650	2,650	10,400	11,850	12,175	10,035	11,275
75	167	3,150	4,000	4,250	2,900	2,250	8,450	9,400	10,100	7,845	7,920
100	212	2,650	2,850	3,350	2,150	1,550	6,950	6,825	7,725	6,045	4,771

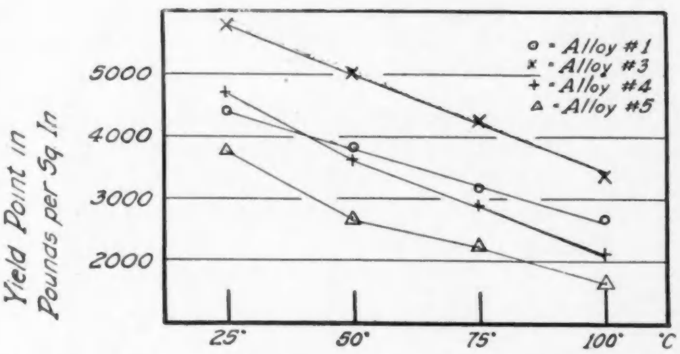


Fig. 6—Relation between the Yield-Points and the Temperature

deg. fahr.) than does that of alloy No. 1, and that the yield-point of tin-base alloys is higher at all temperatures above 50 deg. cent. (122 deg. fahr.).

The yield-point of alloy No. 2, curves of which are not given, is slightly higher at room temperature than that of alloy No. 3, but at 50 deg. cent. (122 deg. fahr.) its yield-point is slightly less than that of alloy No. 3; so, any advantage gained by using alloy No. 2 in a bearing is lost if the bearing heats to 50 deg. cent. (122 deg. fahr.), or over, insofar as the yield-point is concerned.

In Fig. 7, curves are given showing the variation of the ultimate strength with the temperature. Here, as with the yield-point, alloy No. 3 has the maximum value throughout the temperature range and alloys Nos. 1 and 3 maintain their strength better, having a higher ultimate strength at a temperature above 60 deg. cent. (140 deg. fahr.) than either alloy No. 4 or alloy No. 5, which contain lead, even though the ultimate strength of alloy No. 1 is less than that of either alloy No. 4 or alloy No. 5, at room temperature. The ultimate strengths of the four alloys at 100 deg. cent. (212 deg. fahr.) stand in the same relation to each other as their respective yield-points.

Concerning the Brinell hardness tests, it is noted that the Brinell hardness values obtained for the tin-base alloys are considerably lower than those usually given. This difference may be due to the small percentage of impurities in the alloys used in this investigation, as compared with similar alloys as ordinarily prepared. Curves showing the variations of the Brinell hardness with temperature are given in Fig. 8 on page 154. Here again, alloy No. 3 has a maximum value throughout the temperature range. There is no evident relation between the relative magnitude of either the ultimate strength or yield-point and the Brinell hardness.

The hardness of alloys Nos. 4 and 5, however, drops off very rapidly with increasing temperature, while alloys Nos. 1 and 3 maintain their hardness, each having a greater hardness at 100 deg. cent. (212 deg. fahr.) than alloy No. 4, and alloy No. 1 having the same hardness value as that of alloy No. 5 at this temperature.

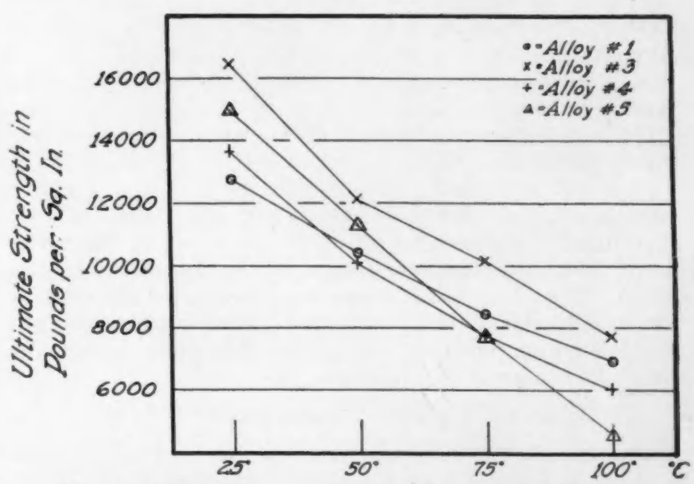


Fig. 7—Curves Showing the Variation of the Ultimate Strength with the Temperature

Table 6—Brinell Hardness of Alloys at Different Temperatures

Temperature		Brinell Hardness[7]				
		Alloy No.				
deg. cent.	deg. fahr.	1	2	3	4	5
25	77	17.2 (28.6)	22.3 (28.3)	22.3	22.4	19.7 (19.5)
50	122	13.8	......	18.2	15.8	16.8
75	167	11.1	......	14.8	11.3	11.4
100	212	8.2 (12.8)	......	11.3	7.5	8.2 (8.6)

[7]The values shown in parentheses are taken from the specifications of the American Society for Testing Materials.

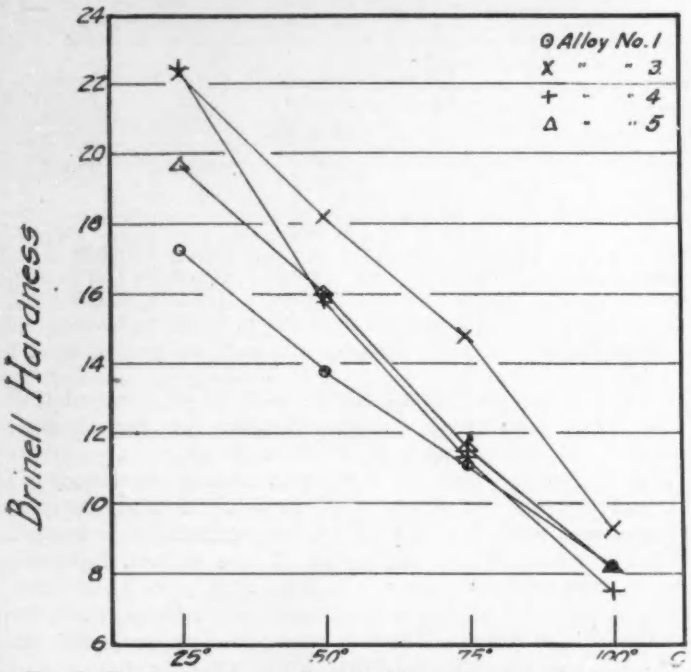


FIG. 8—VARIATION IN THE BRINELL HARDNESS WITH CHANGES IN TEMPERATURE

EFFECT OF LONG-PERIOD HEATING

A babbitted bearing which has given good service often will gradually become soft and "wipe out" for no apparent reason. As a working hypothesis it was thought that this failure with age might be due to softening from prolonged heating, causing an annealing action. To determine the validity of this tentative hypothesis, compression specimens of alloys Nos. 1, 3, 4 and 5, were heated in an oil-bath for from one to six weeks at temperatures between 90 and 100 deg. cent. (194 and 212 deg. fahr.). They were then tested at room temperature with the results given in Table 7.

A study of Table 7 indicates, for alloys Nos. 1, 3 and 4, that heating at 100 deg. cent. (212 deg. fahr.) for 42 days has no appreciable effect on the value of the yield-point when the specimens are cast in the manner indicated. For alloy No. 5, however, there is a very evident decrease in the value of its yield-point with the prolonged heating which, however, evidently takes place within the first two weeks of the heating.

EFFECT OF SMALL PERCENTAGES OF LEAD

The specifications for high-grade tin-base alloys such as Nos. 1, 2 and 3, call for a low lead content, generally not to exceed 0.35 per cent. Many believe and Jesse L. Jones has presented experimental evidence in his book on Babbitt and Babbitted Bearings, previously cited, that percentages of lead even up to 5 per cent are not harmful but possibly beneficial. We have therefore investigated the effect of small percentages of lead on the yield-point and ultimate strength of alloy No. 2 at room temperature and at 75 deg. cent. (167 deg. fahr.). The alloys were prepared by adding metallic lead to the No. 2 babbitt, in amounts shown by the chemical analysis given, together with the yield-points, in Table 8.

The addition of up to 5 per cent of lead to this babbitt seems to have no very appreciable effect on its mechanical properties in compression, at room temperature or at 75 deg. cent. (167 deg. fahr.), under the conditions of test used. We think, however, that this should not too greatly influence toward the raising of the lead tolerance in the tin-base bearing-metal specifications until much more work is done along this line, particularly to determine the possible effect of small percentages of lead on the resistance to repeated impact.

TABLE 7—EFFECT OF PROLONGED HEATING AT 100 DEG. CENT. (212 DEG. FAHR.) ON THE YIELD-POINT

Heating Period, days	Yield-Point, lb. per sq. in.				
	Alloy No.				
	1	2	3	4	5
0	4,550	....	5,750	4,650	3,750
7	4,500	....	5,500	....	3,450
14	4,600	....	5,800	4,250	3,200
28	5,025	....	5,650	4,750	2,800
42	4,900	....	5,950	4,850	3,150

[a]One specimen only; all other values are the average of two specimens.

SUMMARY AND CONCLUSIONS

An apparatus is described for determining the yield-point and ultimate strength of white-metal bearing alloys at temperatures up to 100 deg. cent. (212 deg. fahr.). A new design of heating apparatus is described for determining the Brinell hardness of metals at temperatures up to 100 deg. cent. (212 deg. fahr.).

The results of compression tests and Brinell hardness

(*Concluded on page* 162)

TABLE 8—EFFECT OF SMALL PERCENTAGES OF LEAD ON THE YIELD-POINT AND ULTIMATE STRENGTH

Metallic Lead Added, per cent	Yield-Point, lb. per sq. in.		Ultimate Strength, lb. per sq. in.	
	Temperature		Temperature	
	25 deg. cent. (77 deg. fahr.)	75 deg. cent. (167 deg. fahr.)	25 deg. cent. (77 deg. fahr.)	75 deg. cent. (167 deg. fahr.)
0.00	6,150	4,000	15,175	9,397
0.26	5,850	3,700	15,640	10,010
0.51	5,750	3,300	14,025	9,763
1.01	6,300	.....	......	......
1.25	6,000	4,100	16,380	10,600
5.04	5,850	3,850	15,330	9,725

The Application of Steam Power to an Automotive Truck

By LEWIS L. SCOTT[1]

CHICAGO TRUCK AND TRACTOR MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

IN connection with possible changes of detail in the design of automotive trucks, that have been brought to view by increased speed and the use of pneumatic tires, and because of the present status of the fuel situation, it occurred to me that a truck having an engine steam engine is located crosswise on the truck frame, as shown in Figs. 1 and 2, about where the transmission usually is on a truck driven by an internal-combustion engine. No transmission or clutch is used. In our latest design the engine is located just at the rear of the

FIG. 1—VIEW OF THE COMPLETE TRUCK SHOWING CROSSWISE POSITION OF THE ENGINE ON THE TRUCK FRAME

driving a rear-axle worm direct through a drive-shaft equipped with a 5 to 1 gear reduction at the axle and that could be operated without any transmission or clutch, would be interesting to truck designers. A description of the steam-operated 2-ton truck developed by E. C. Newcomb and me, which offers a solution to these problems, should consequently be of general interest.

In my previous paper, Steam Automotive System,[2] the details of design of the steam engine used on this 2-ton truck were described, but the engine has been simplified since that time. The changes in the construction of the engine relate to valve gear, crankshaft and cam design, and include many details that would not be of particular interest at present because of a lack of general knowledge of the problems involved. However, as very little is known concerning an engine that uses high pressures and temperatures for this kind of service, the details of its development can best be discussed thoroughly in a separate paper and I hope to do this later.

This truck was designed to carry a 2-ton load. The

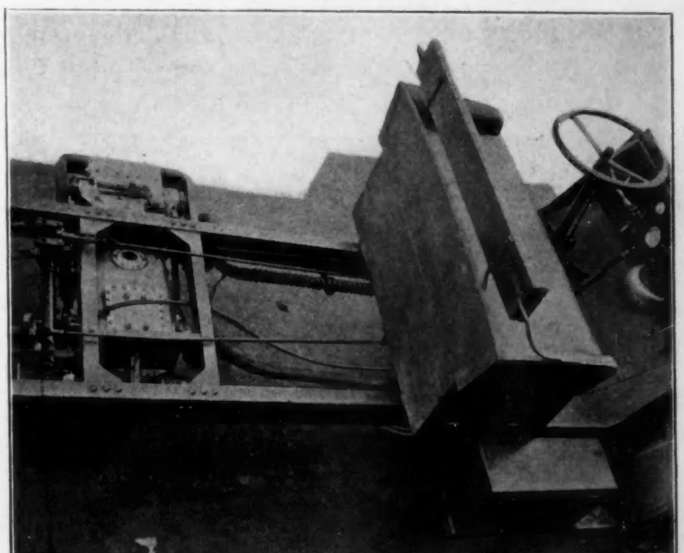


FIG. 2—VIEW LOOKING DOWN ON THE TRUCK SHOWING RELATION OF ENGINE LOCATION TO THE DRIVER'S SEAT

[1] M.S.A.E.—Chief engineer, Standard Engineering Co., St. Louis.
[2] Printed in the November, 1919, issue of THE JOURNAL, p. 353.

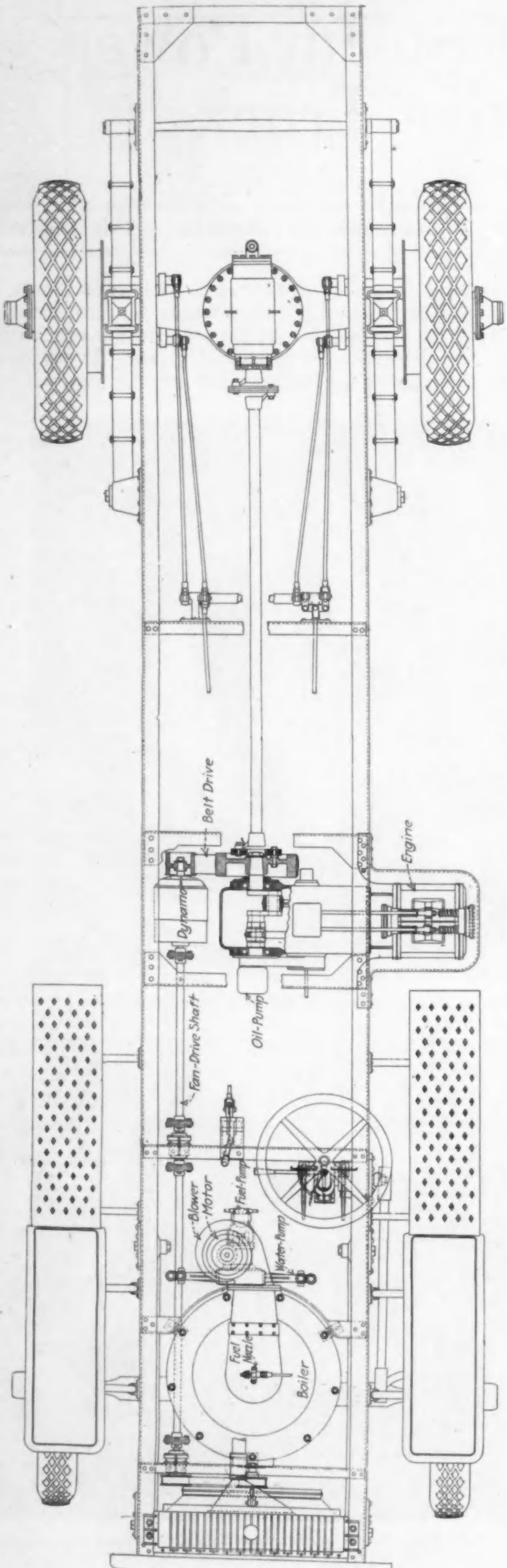


Fig. 3—Plan View of the Complete Truck Showing the Location of the Crankshaft, the Drive-Shaft and the Dynamo

driver's seat and can be mounted either horizontally or vertically as desired. By so locating the engine the steam and the exhaust lines are shortened and so is the shaft that drives the radiator fan, but the axle drive-shaft is thus made longer. The engine shaft is directly connected to the worm-driven axle through a drive-shaft. The cam-shaft, which operates the valves, is adapted to be shifted axially for controlling the cut-off and reversing the engine when backing the truck. A pedal operated by the left foot, similar to the clutch pedal on a truck driven by an internal-combustion engine, is used to shift the cam.

A sectional drawing of the engine, showing the crank-shaft, drive-shaft and dynamo drive is reproduced in Fig. 3, and the relative positions of the various parts of the system are brought out in Fig. 4. It is surprising how free this engine is from vibration and how smoothly it operates, even without a flywheel. The engine has two double-acting cylinders of 4-in. bore and 5-in. stroke and gives the same number of impulses as does an eight-cylinder internal-combustion engine, with the added flexibility of steam. It will be noted that a one-piece crank-shaft is used, with plain connecting-rod bearings, and two ball bearings for the journals. The engine flywheel serves as a pulley to drive the dynamo and affords an arm to which to attach the thermoid coupling. The front end of the dynamo shaft serves as a drive for the radiator fan.

Advantageous Features

The features of special interest in this steam power-plant are that

(1) Because the engine is directly connected to the drive-shaft, it cannot be run unless the rear wheels also turn. This prevents racing the engine or allowing it to run when loading or unloading the truck, which is a common practice with some drivers
(2) All kinds of road can be negotiated with the same gear-ratio between the engine and the rear axle
(3) The dump type of body can be used satisfactorily because a steam hoist can be installed if desired
(4) Driving is more simple and the number of accidents should be reduced for this reason
(5) The rapid acceleration is conducive to safer operation at street corners and intersections
(6) No gear-shifting is necessary when starting
(7) Carbon does not collect in the engine
(8) The valves do not require re-grinding
(9) Dust cannot be sucked into the engine and the truck should, on this account, remain operative for longer continuous periods than in the case of trucks driven by an internal-combustion engine

The boiler is located under the hood as shown in Fig. 5. Steam can be raised in less than 1 min. from a cold start. No effort is required in getting up steam other than turning a switch. No stuffing-boxes are used on the engine or pump. The water and fuel-pumps are operated by an electric motor, which is controlled by a switch on the steam gage.

Fuel oil, gas oil, kerosene, gasoline or any mixture of these fuels can be used. This makes possible the utilization of 80 per cent of the crude oil available. It is possible also to use powdered coal or coke as a fuel. The fuel is cleanly and completely burned, without experiencing any of the long list of troubles common to the explosive type of engine that are due to the present grade of gasoline.

The lubricating oil, which can be of the same grade as that used to lubricate internal-combustion engines, is

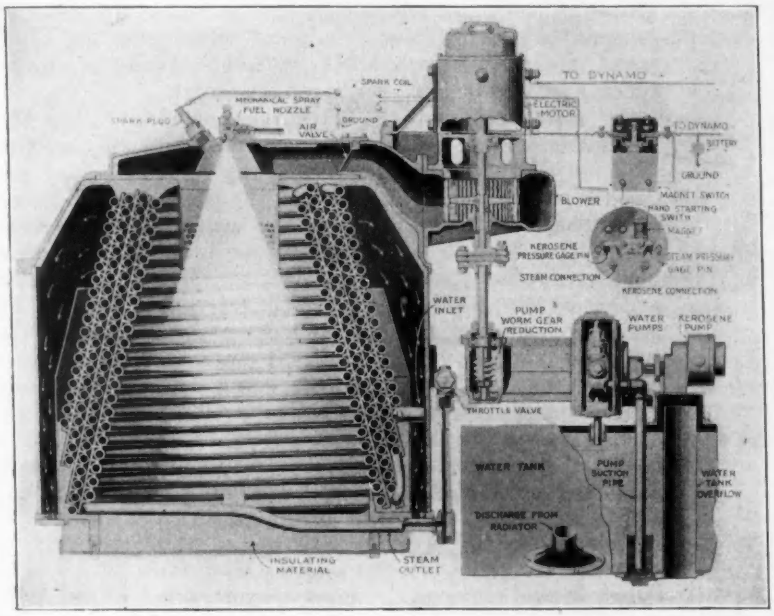


Fig. 4—The Relative Position of the Different Parts of the System

carried in the crankcase of the engine. All parts in the crankcase are lubricated by splash. A small valveless oil-pump is used to pump oil from the crankcase to the steam line for lubricating the cylinders. The engine is of the poppet-valve type, and the valves require little or no oil.

The weight of this steam powerplant, including the engine, boiler and water, is practically the same as that of an internal-combustion engine powerplant of similar capacity, inclusive of the cooling system, clutch and transmission.

Torque Curves

Fig. 6 on page 158 shows the characteristic torque curves of the internal-combustion engine and the steam engine powerplants, the two becoming identical at 1000 r.p.m. The particularly noteworthy feature is the ability of the steam engine to maintain a constant horsepower over almost the entire range of speed on the short cut-off, thus insuring maximum economy of operation above 300 r.p.m.

Fig. 7 on page 158 shows the respective performances of these powerplants when applied to a 2-ton truck having a gross weight, when loaded, of 11,000 lb. Each is a high-speed truck equipped with 8 x 40-in. pneumatic tires on the rear wheels and has a 5 3/7 to 1 gear-ratio in the axle. The low and the intermediate gear-ratios between the engine and the rear wheels are assumed to be 50 to 1 and 25 to 1 respectively. For purposes of illustration, only three speeds are assumed. This is not in accordance with usual practice for this particular case, but it introduces sufficient gear changes to demonstrate the method of operation. The efficiency of the worm-gear axle is assumed to be 90 per cent in each case and the transmission also is assumed to be 90 per cent efficient.

It is noteworthy that the steam-engine curve in Fig. 7 on page 158 meets the tractive effort of the truck equipped with the internal-combustion engine at 22 m.p.h. and that the steam-engine performance is above that of the internal-combustion engine at all other points. When grades become steep, gear-shifting must be resorted to in using an internal-combustion engine powerplant. With a truck so driven, when starting a load up a heavy grade it is very difficult to change to a higher gear without stalling the engine and many drivers will continue to use low gear, racing the engine to acquire speed. The truck driven by a steam engine does not encounter this difficulty. Fig. 8 on page 158 shows the performance on grades of each of the powerplants shown in Fig. 7 on that page.

Engine Control

In regard to engine control, the truck is started forward simply by opening the throttle. For an extreme pull, the cam is shifted into the long cut-off position by pushing the left pedal forward until it comes to a stop. As no latch is provided in the long cut-off, the driver naturally will release the left pedal, which will shift the cam to the short cut-off. In the short cut-off position any kind of running can be accomplished, even the climbing of a 14-per cent grade at 8 m.p.h. When extreme grades are encountered, the cut-off can be lengthened by pressing the left pedal forward.

To reverse the engine for backing the truck, the left pedal is moved forward until it strikes the long cut-off stop; then, by tilting the pedals slightly, it will clear the long cut-off stop and can be pushed forward until it stops. This is the reverse position. It is possible to use the reverse as an emergency brake, thus eliminating the necessity of equipping the truck with air brakes.

All parts of the powerplant are accessible. The boiler top can be removed and the coils exposed within a few minutes. The spark-plug and the fuel-spray nozzle are located at the top of the boiler and can be removed quickly. Access to the fuel and water-pumps is afforded by the ample space allowed under the foot-boards. The gages are mounted on the dash and when the hood is raised their connections are exposed. The two connecting-rod bearings are the only ones in the engine that are adjustable and they can be reached easily by removing the back cover of the engine case. The engine can be removed from the truck within 10 min. It should be borne in mind that this type of engine requires no valve-grinding or carbon-deposit removal, and that it has no carbureter, magneto, spark-plugs and the like.

In view of the fact that this truck has no transmission, in the accepted sense of this term, there is a material

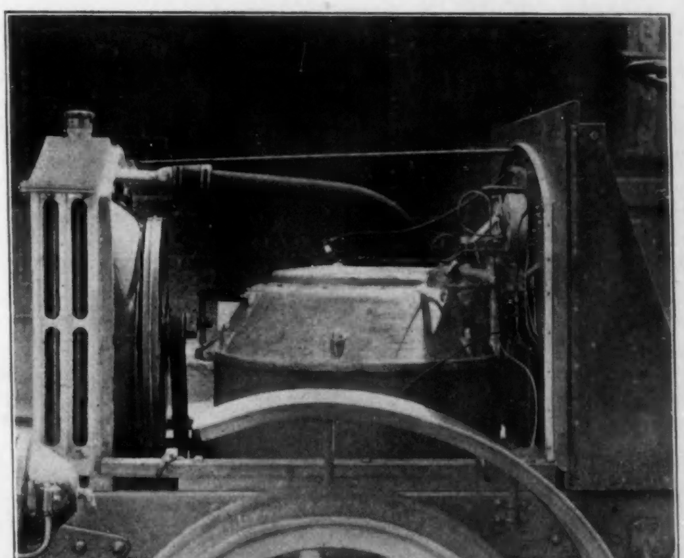


Fig. 5—The Boiler Is Located under the Hood

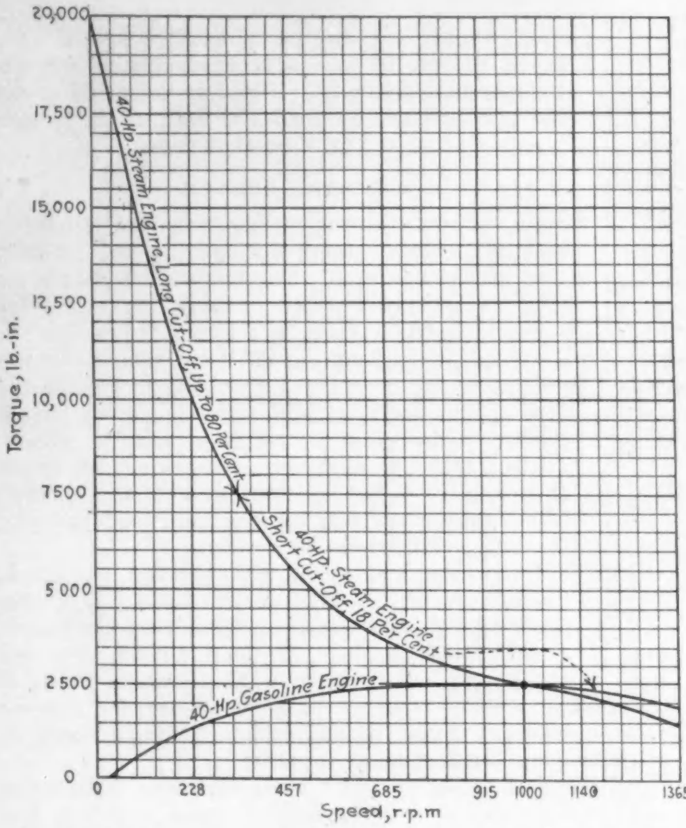


FIG. 6—CHARACTERISTIC TORQUE CURVES OF A 40-HP. INTERNAL-COMBUSTION ENGINE AND A STEAM ENGINE DEVELOPING THE SAME POWER

saving in power. This type of steam engine shows about the same efficiency at one-quarter load as at full load, which is must better performance than that of the internal-combustion engine. I understand that gearbox efficiency becomes as low as 70 per cent in some instances.

With a gear-reduction at the rear axle of from 5 to $5\frac{1}{2}$ to 1, it is possible to slip the rear wheels on a dry pavement when the truck is fully loaded. When the truck is traveling 25 m.p.h., the engine speed is about 1200 r.p.m.

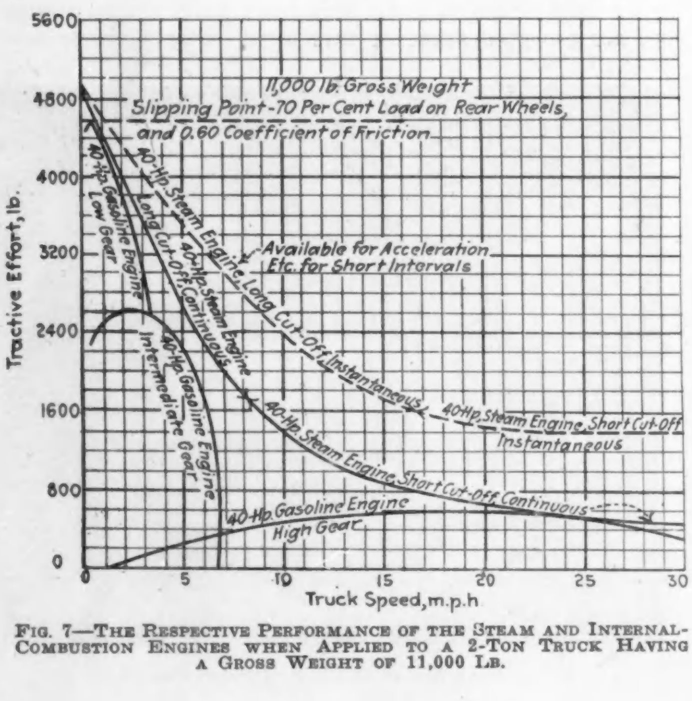


FIG. 7—THE RESPECTIVE PERFORMANCE OF THE STEAM AND INTERNAL-COMBUSTION ENGINES WHEN APPLIED TO A 2-TON TRUCK HAVING A GROSS WEIGHT OF 11,000 LB.

The high torque at low engine speeds makes the gearbox unnecessary and allows this plant to fit into the high-speed pneumatic-tired truck without excessive engine speed and without transmission or clutch.

As an example of the advantage of eliminating the transmission and clutch on trucks used in bus service in some of the large cities as many as 1000 stops per day are made, requiring several thousand gear-changes. Frequent stops and starts with a heavy load are very destructive to a truck equipped with an internal-combustion engine, with which a transmission and a clutch are required. There has been considerable comment on the adaptability of the internal-combustion engine driven truck to bus service. The steam plant is ideal for this service, some of its advantages being smooth operation, rapid acceleration, flexibility, self-starting with no chance of "killing" the engine at some critical moment, that when the bus stops the engine also stops, and that exhaust steam heat for cold weather is available at no extra expense.

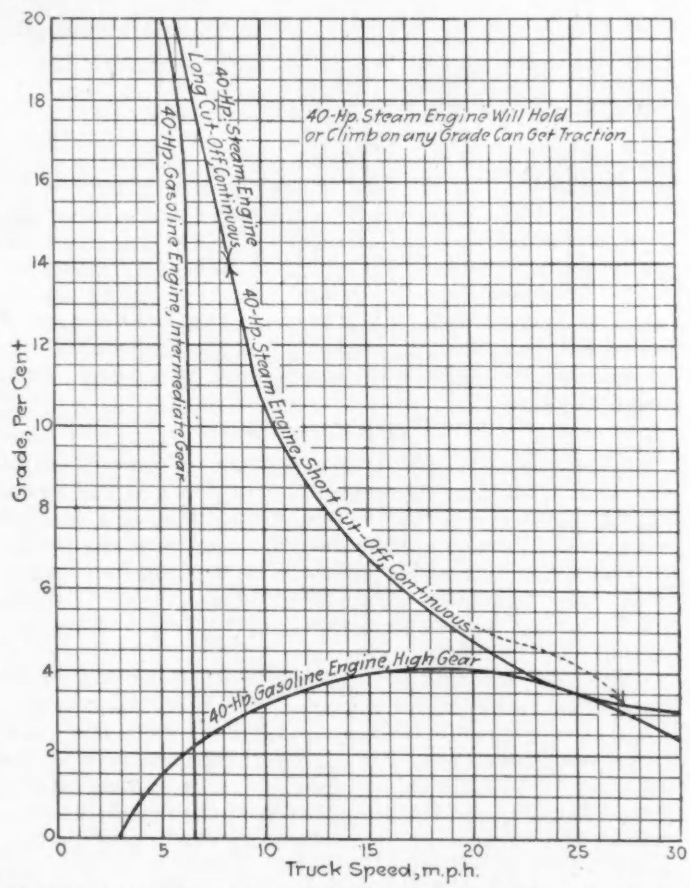


FIG. 8—COMPARATIVE PERFORMANCE OF THE TWO TYPES OF POWER-PLANT ON GRADES

At atmospheric temperatures of 85 to 90 deg. fahr., we have driven a fully loaded truck 700 miles on the streets of St. Louis with only one tank of water. In cool weather, this water mileage is increased greatly. Long water mileage is important because it reduces the foreign matter brought into the system and no trouble is caused by encrustation of the boiler tubes; also, it permits the use of alcohol to prevent freezing in cold weather.

FUEL, OIL AND WATER CONSUMPTION

With a load of 4400 lb. we get from $5\frac{1}{2}$ to 6 miles per gal. of fuel, with either kerosene or fuel oil, and 300 miles per gal. of lubricating oil, with solid tires. A communi-

TABLE 1—ACCELERATION TESTS—CHASSIS ONLY—NO LOAD[3]

From Zero Speed to M.p.h.	SOUTH Time, Sec.					Average Time, Sec.	Acceleration, M.p.h. per Sec.	NORTH Time, Sec.					Average Time, Sec.	Acceleration, M.p.h. per Sec.
	1	2	3	4	5			1	2	3	4	5		
10	3.6	..	3.0	2.7	3.0	3.08	3.25	3.0	3.0	3.0	2.6	2.7	2.87	3.49
15	5.4	..	4.0	4.7	4.4	4.62	3.25	4.0	4.8	4.4	4.4	4.4	4.40	3.41
20	7.2	7.2	6.8	6.2	6.7	6.82	2.93	5.8	7.8	6.9	7.4	6.4	6.86	2.92

[3]Using long cut-off for starting; then using short cut-off. Run was made on level ground.

cation from one of the large oil companies dated Sept. 30, 1920, quoted water-white kerosene of 41-deg. specific gravity, in tank-car lots, at 11 cents per gal. f.o.b. Tulsa, Okla. Gasoline was quoted in similar quantities at 23 cents per gal. f.o.b. Tulsa, and 24-deg. specific gravity fuel oil in tank-car lots was priced at 8¼ cents per gal., f.o.b. Sand Springs, Okla. It should be remembered that the radiator is entirely empty when the truck is not running. When the truck is running the radiator is used to condense the steam into water, which then runs into the water-tank. The parts containing water are located around the boiler, which will retain heat for 12 hr.

In localities where the water contains large quantities of calcium and magnesium, it can be run through a small tank containing a mineral substance resembling clay or shale that is mined in South Dakota and makes the water softer than rain water. A tank of the size used in residences for heating water will soften 1000 gal. per day. This material is highly charged with exchangeable sodium. It is placed in a filter container in this condition and the water to be softened is passed through it. Having a strong affinity for the calcium and the magnesium in the water, the substance combines with these elements and gives up its sodium to the water in proportionate amounts. When the substance has become charged with calcium or magnesium, by a simple process of admitting a solution of sodium chloride the mineral substance is restored to its original state.

The saving in fuel and oil costs in comparison with the internal-combustion engine driven truck is evident, to say nothing of the saving in unkeep and repair due to the freedom from valve-grinding and carbon removal and to the elimination of the transmission and clutch.

On a 2-ton truck operating 60 miles per day, I estimate that a saving in fuel cost of $1 per day can be effected with the steam powerplant, thus saving $300 per year. The saving on lubricating oil at 25 cents per day would amount to $75 per year. Adding the saving because of the elimination of valve-grinding and carbon removal, about $30 per year, and the saving on general overhauling, about $100 per year, brings the total estimated saving to $505 per year.

ACCELERATION TESTS

It is well known and generally recognized that any properly made steam car can accelerate much more quickly than can one driven by an internal-combustion engine. Attention is called again to the long cut-off curve in Fig. 7. Acceleration tests of this truck were made at St. Louis by representatives of the Fifth Avenue Coach Co., of New York City, in November, 1920. Table 1 gives the results obtained in runs made with the chassis only, with no load, on a level street. The nominal diameter of the rear tires was 40 in. and their actual diameter 43 in. The speedometer was checked by counting the number of wheel revolutions per mile, this number being 938. The weights are as follows: Chassis, 5960 lb.; allowed for three passengers, 505 lb.; total weight, 6465 lb. The weight on the front wheels was 3100 lb. and that on the rear wheels 2860 lb. Under the same conditions as stated for the tests in Table 1, but using the long cut-off throughout, the results given in Table 2 were obtained.

TABLE 2—ACCELERATION TESTS—CHASSIS ONLY—NO LOAD[4]

From Zero Speed to M.p.h.	Time, Sec.		Average Time, Sec.	Acceleration, M.p.h. per Sec.
	1	2		
10	....	3.0	3.0	3.33
15	....	4.5	4.5	3.33
20	7.0	7.2	7.1	2.82

[4]Using long cut-off throughout.

In runs made after the body and the load had been

TABLE 3—ACCELERATION TESTS UNDER LOADED CONDITIONS—TOTAL WEIGHT, 11,065 LB.

From Zero Speed to M.p.h.	SOUTH Time, Sec.					Average Time, Sec.	Acceleration, M.p.h. per Sec.	NORTH Time, Sec.					Average Time, Sec.	Acceleration, M.p.h. per Sec.
	1	2	3	4	5			1	2	3	4	5		
10	5.0	4.0	4.2	..	3.2	4.10	2.44	3.4	4.2	3.2	3.8	3.2	3.51	2.85
15	9.0	6.4	7.2	7.0	6.0	7.12	2.11	6.0	6.5	5.8	5.9	6.0	6.04	2.30
20	12.0	11.0	11.7	10.3	11.1	11.22	1.78	10.0	10.0	9.5	8.9	8.8	9.44	1.95

placed on the chassis, the weight complete was 10,560 lb.; allowed for three passengers, 505 lb.; total weight, 11,065 lb. The weight on the front wheels was 3795 lb. and that on the rear wheels 6765 lb., without passengers. The acceleration test results are given in Table 3 on page 5.

Alternate readings were taken of the blower periods, on and off, in runs made with the chassis loaded. The first run covered a distance of 4.95 miles with no stops. The blower was on 33.8 per cent, and off 66.2 per cent of the time. Under similar conditions, except that sixteen 5-sec. stops were made and that the distance was 5 miles, within the elapsed time of 19 min. and 19 sec., the blower was on 30.5 per cent, and off 69.5 per cent of the time. Table 4 gives the results of braking tests made on level ground.

TABLE 4—STEAM BRAKE TESTS

Run No.	Time, sec.	Distance, ft.	Speed, m.p.h.	Direction
Reverse, with no steam				
1	8.4	54	15	South
2	8.0	60	14	South
3	10.0	63	16	North
4	9.0	72	14	North
5	10.0	81	15	North
Reverse, with steam				
1	7.4	51	15	North

Acceleration tests were made also on the grade locally known as Dead Man's Hill, the loaded weight being 11,065 lb. The run to the bottom of the hill is 7.75 miles, which was made in 24.84 min. at an average speed of 19.2 m.p.h. The speed at the bottom of the hill was 28 m.p.h. and the lowest speed on the hill, which has a 10-per cent grade and is a winding road, was 15 m.p.h. The results of these tests are given in Table 5.

TABLE 5—ACCELERATION TESTS ON DEAD MAN'S HILL—TOTAL WEIGHT, 11,065 LB., GRADE 10 PER CENT.—WINDING ROAD

From Zero Speed to M.p.h.	Time, Sec.			Average Time, Sec.	Acceleration, M.p.h. per Sec.
	1	2	3		
5	....	3.2	3.7	3.4	1.470
10	8.0	4.8	4.8	4.8	2.080
15	27.0	22.6	21.8	22.2	0.675

A test was made on the failure of the spark to light the fuel spray. The spark-plug wire was disconnected from the spark-plug and the fuel was then turned on, thereby filling the combustion-chamber with kerosene vapor. When the fire was lighted again in the normal way, there was no explosion nor any smoke.

Another test was made on the failure of the fuel system. The fuel was prevented from entering the combustion-chamber, thereby allowing the boiler to fill with water after the temperature was sufficiently low. After a short period the engine was cut off by the pressure gage. No damage whatever occurred.

A third test was made on the failure of the water system. The water was by-passed, thereby allowing the temperature to climb. The temperature reached 780 deg. fahr. and then the fuel was shut off by the solenoid valve.

Additional tests were made on Nov. 14, 15 and 16, 1920, the total loaded weight being 11,065 lb. in each case, with results as stated under Runs Nos. 1, 2, 3 and 4, following:

ADDITIONAL RUN NO. 1

Total distance, miles	49.9
Elapsed time, hr.	3¼
Starting time from cold boiler, min.	1
Temperature at 0.2 miles distance, deg. fahr.	650
Miles run on stored steam	0.4
Number of stops made	178
Average speed, m.p.h.	15.3
Water used, gal.	1
Fuel used, gal.	9⅛
Miles per gallon of fuel	5.49

Note:—After 3 hr. 3 min. the brush on the dynamo became loose.

ADDITIONAL RUN NO. 2

Total distance, miles	35.5
Elapsed time, hr.	1¾
Average speed, m.p.h.	20.3
Maximum speed, m.p.h.	32.0
Minimum speed, Solomon Hill, m.p.h.	13.0
Fire cut off on 10-per cent Solomon Hill grade	3 times
Miles per gallon of fuel	6.59
Water used, gal.	Slightly less than 2

ADDITIONAL RUN NO. 3

Total distance, miles	6.2
Fuel used, gal.	1

Note:—Appeared to run the same as with kerosene, with no odor or smoke.

Additional Run No. 3, made on fuel oil by Messrs. Wotton and Reese, was only for the purpose of testing the operation of the truck. It was limited to a 6-mile run, which was insufficient to warm up to efficient operation. No changes were made in the system in any way. We simply changed from kerosene to fuel oil and then started immediately, showing that almost any kind of fuel can be used without very much alteration. Many times I have changed from kerosene to gasoline, then to

ADDITIONAL RUN NO. 4

Total distance, miles	30.9
Elapsed time, hr.	1.6
Atmospheric temperature, deg. fahr.	40
Average speed, m.p.h.	19.3
Fuel used, gal.	4 2/3
Miles per gallon of fuel	7
Water used, gal.	1

(*Concluded on page* 162)

FIG. 9—THE LOADED TRUCK WHICH WAS USED IN THE TESTS

Automotive Obligations Toward Highway Development

By H. W. ALDEN[1]

ANNUAL MEETING ADDRESS

IN opening this Highway Session, I wish to bring to your attention very clearly and emphatically the responsibility of the automotive industry for some things besides the actual building and selling of motor cars. We all know that the progress of civilization can be measured very largely by advances in means of communication. The transfer of thoughts and messages by wire and wireless has made wonderful advances of a fundamental and revolutionary nature in recent years. On the whole, the transportation of things from place to place has not made such strides. This is fundamentally due, I believe, to the fact that practical performance can be developed in laboratory investigations better in the former case than in the latter.

In electrical matters, such as the telephone and telegraph both with and without wires, the companies controlling the work have exhibited great foresight and shown great energy in all its phases. Perhaps it has been necessary to their very life that they should do so, but it is a fact that they have done so. This is far from true in the automotive industry. We have been concerned mostly with the actual development and production of the motor car and, as an industry, have stopped there without developing those allied activities which are vital to the long-time success of the business. Our railroads are a good example to follow in principle. The roadbed and the equipment operating on that roadbed have been improved and developed hand-in-hand by the same general guiding influences. The wonderful advance in both in the last 20 years is due fundamentally to this unified control of these two elements.

In the matter of highway transport, we find a different condition. It is true that today we have far better highways than formerly, but I believe the ratio between the demand on the highways and their ability to meet that demand has, on the whole, gone down rather than remained constant. The increase in numbers and capacity of motor cars has been greater than the extension and improvement of highways. It is my opinion that the responsibility for this rests squarely on the shoulders of the automotive industry itself. It is easy to criticise the highway engineer, but I venture to assert that the average highway engineer can come nearer qualifying as an automotive engineer that his automotive brother can as a highway engineer. If I should ask those present to stand up who have given serious thought to highway design and construction, not many chairs would be vacated. We cannot continue increasing the number and capacity of motor cars for our own profit and shirk the responsibility of helping in highway development. That is one of the facts I want to emphasize as forcefully as I know how. The long-time success of our business is inextricably interwoven with highway development. Unless this situation is more clearly understood and its lessons learned by the industry, then the industry will not advance as it might.

My sympathy lies very largely with the highway engineer. Our engineering schools have, on the whole, been asleep and have failed to provide instruction in this work. Consequently, the highway engineer has had to blaze his own trail until very recently. Considering his handicap of political jobbery, it has been an uphill task. Until very recently, I repeat that the automotive industry has been occupied too much with making money and not enough with those allied activities which, for its own good, should have had its hearty cooperation all the time.

Merchandise transportation depends not only on cars and roadbeds, automobiles and highways, boats and waterways and, I might add for the future, airplanes and blue sky, but on the manner of use of these agencies. Here again we can learn a lesson from railroad experience. In the past the development of freight terminals and rail transportation has been under the same general guidance and the development of the two has been consistent and logical. The recent projection of the automobile into the transportation field has made possible wonderful changes in the methods of distribution of all commodities, but here again the automotive industry, as a whole, has neglected its full responsibility. It has failed to shoulder this responsibility for the correct use of the new instrument which it has produced, and for the proper correlation of it with previously existing instruments. I believe we are emerging gradually from our fools' paradise of money-making into a realization of this larger responsibility. How the railroads, highways and waterways can be best joined together in the general function of merchandise transportation is worthy of any man's time and intensive study. The correct solution and the proper arrangement of these three agencies will have a wonderful effect on the future of our industry.

Freight cars average little better than 25 miles per day, due to terminal delays which could be eliminated largely if the motor trucks and railroads were in proper relation. This daily average could be lifted easily to 75 or 100 miles if the inefficiency of present terminal methods were eliminated. This is no idle dream. The basic trouble is that railroads are doing an enormous amount of less-than-carload, short-haul work for which they are not so well equipped as is the motor truck. The average distance that each ton of freight is hauled by rail is less than 200 miles, due to this large amount of short-haul tonnage. A proper re-arrangement wherein the motor truck would do the short-haul and the less-than-carload work and the railroads the long-haul work would give us a regular freight transportation more speedy than today's average express shipments and at a cost far less than anything dreamed of today. However, I have seen little indication of study of this problem by the automotive industry as a whole, or of cooperation with the railroads in its solution, until very recently. We cannot pass

[1] M. S. A. E.—Vice-president, Timken-Detroit Axle Co., Detroit.

the blame on to the railroads. The responsibility is our own. It is a challenge to the brains of the automotive industry and, unless we get busy and assist in the solution of this problem, the progress of the truck industry will be slow where it might be rapid. The details of these questions are numerous, but they are not difficult of solution. They must, however, be honestly faced and understood Then, if honestly attacked, the results will revolutionize our transportation business.

I am fairly well acquainted with what our industry has done in the fields of highway development and merchandise transportation, but I repeat that what has been done is only a drop in the bucket. I am greatly pleased that our Society is showing signs of life in these two directions, as they are at the very foundation of our future success and expansion. It behooves every automotive engineer to devote a goodly share of his time to studying these two questions. I hope what I have said will direct our attention more and more to these fundamental problems, the solution of which is as much our responsibility as it is that of the railroad and highway engineers.

PRESIDENTIAL ADDRESS OF J. G. VINCENT

(*Concluded from page* 100)

construction, improved installation of powerplant auxiliaries and cleaner-cut plane design, accomplished by the elimination of wires to a reasonable extent and the substitution of inherently rigid structural elements. The reduction of head resistance resulting from these improvements will admit of higher speed with the same power, or the same speed with reduced power, or advantage may be taken of securing a higher ratio of useful load. We should encourage in every possible way the construction of additional landing fields which essentially must precede the development of commercial aviation on an extensive scale.

The fuel problem has not as yet affected airplane engine design materially, since the limited quantities of high-test fuel required at present for aircraft operation are easily obtainable. However, it would appear that ultimately the same fuel would be used in both cars and airplanes.

In the matter of lubricating oil, airplane engines are now satisfactorily handled with mineral oils of somewhat heavier body than used for ordinary automobile engines.

Perhaps the most conspicuous tendency in airplane engine design at the present time is to pay more attention to efficient operation at altitudes and under reduced throttle conditions obtaining during average flights. This involves in some cases special precautions against running wide-open near the ground, except for short periods with the aid of special fuels to guard against preignition and detonation. In this manner it is possible to effect considerable savings in fuel consumption at altitudes together with an increase of available power under normal flying conditions.

A STEAM POWER AUTOMOTIVE TRUCK

(*Concluded from page* 160)

fuel oil and after that to a mixture of the three fuels, without any noticeable change in operating performance.

Fig. 9 on page 160 shows the truck equipped with body and loaded. It will be noted that pneumatic tires are used. This truck has been run at 35 m.p.h., which was by no means the limit of its speed.

Table 6 gives the mileage per gallon of fuel and per gallon of oil obtained with several different types of truck in tests conducted by a prominent oil refining company.

Future Development

It is possible to equip this truck with some disengaging clutch, for coasting, that will increase the fuel and water mileage greatly.

We have a process for using steam to propel a truck or an automobile that will give a fuel mileage on our truck of from 18 to 20 miles per gal. of kerosene or fuel oil, if the details can be worked out in a practical way. It is now in process of development and has been built, but it is still in the experimental stage.

Table 6—Mileage per Gallon of Fuel and of Oil

Type of Truck	Capacity, Tons	Mileage Obtained per Gallon	
		Gasoline	Oil
Bourne	2	4.72	91.3
White	2	5.21	45.3
Packard	3	4.30	128.5
White	5	3.14	20.1

PROPERTIES OF WHITE-METAL ALLOYS

(*Concluded from page* 154)

tests at temperatures up to 100 deg. cent. (212 deg. fahr.) are given for five typical white-metal bearing alloys, including three tin-base alloys, one lead-base and one intermediate alloy, which show that the tin-base alloys maintain their properties the best at elevated temperatures.

The results of tests are given which indicate that up to 5 per cent of lead in a high-grade babbitt does not affect the yield-point or ultimate srength at 25 or 75 deg. cent. (77 or 167 deg. fahr.).

The yield-point of tin-base alloys is not affected by heating for six weeks at about 100 deg. cent. (212 deg. fahr.), but the yield-point is lowered in the lead-base alloy by heating for two weeks at about 100 deg. cent. (212 deg. fahr.).

Highway Road-Construction

By William E. Williams[1]

Annual Meeting Paper *Illustrated with* Photographs and Drawings

Only three road surfaces have given satisfaction for automobile traffic; asphalt, brick and concrete slabs. Thus far the concrete-slab surface is the only one worthy of consideration for such traffic. Many people think that the roadbed should be elastic and that the asphalt and the brick surfaces furnish elastic conditions. Experience has proved that an asphalt surface will not stand up under heavy truck traffic. The brick surface comes nearer to the desirability of the concrete-slab surface than the asphalt.

Fig. 1

The idea that an asphaltic surface is necessary for the riding qualities and preservation of the vehicle is an old one; it has been thrashed out in railroad service and other lines with the result that elasticity in a roadbed is found to have been a mistaken idea. The best roadbed is an absolutely solid one, with as straight a surface as can be obtained. One of the examples of an old theory in regard to elasticity is found in stamp mills that reduce ore. It was believed for generations that a stamp mill should be founded on a heavy timber grillage having masonry underneath, the timber furnishing, as it were, an elastic shock cushion for the stamp-rods. It appeared that, whenever these stamps were founded on solid masonry, the stamp-rods would crystallize and break. The builders of these mills specified in old days that their guarantee would not follow the mill unless it was founded on a timber grillage. This method was discarded by engineers in the copper country, who built heavy masonry foundations with the least possible elasticity and made the stamprods of steel. Then it was found that this type of stamp mill was better than one having an elastic timber-grillage base-construction. The stamprods did not crystallize and break when made of steel.

The road surface should be as nearly rigid as it is possible to make it. It is a mistake to make a road surface which is expected to bend under the movement of traffic, even in the least possible amount that is preventable; for in this way the road is destroyed. The asphalt-surface road, or a brick-surface road, must have a concrete base. The asphalt and brick surfaces aid the concrete base but slightly in sustaining beam loads, or in providing a wider distribution of the load over the surface soil or sub-base of the road; whereas, if the equivalent of the thickness of the asphalt and the brick, and particularly the cost of laying those materials, is expended in producing an extra thickness of the concrete slab, a stronger load-sustaining surface will be obtained than it is possible to get at the same cost with any supplementary facing such as asphalt or brick. It costs more to lay the asphalt or brick for a given depth than it does for the same depth of concrete. A brick surface is substantially 4 in. in depth and is supported by 4, 5 or 6 in. of concrete base, making a total depth of not less than from 8 to 10 in. The relative strength as a beam of that road surface is substantially limited to the thickness of the concrete underneath the brick, say 6 in. as a maximum. A concrete slab of the same relative depth as 4 in. of brick and 6 in. of concrete, would amount to 10 in. The relative load-sustaining capacity as a beam construction would be 36 for the brick surface, being the square of the depth of 6 in., which is the thickness of the concrete base; it would be 100 for the concrete slab, being the square of the depth of the concrete slab. Thus, both brick and asphalt have no chance of being competitors for service on a motor-truck highway. The concentrated loads placed upon the wheels when the heaviest trucks are considered run as high as from 4 to 8 tons under a single wheel. This is on an area perhaps not greater than $\frac{1}{3}$ sq. ft. The

Fig. 2

[1] M.S.A.E.—Consulting engineer, Chicago.

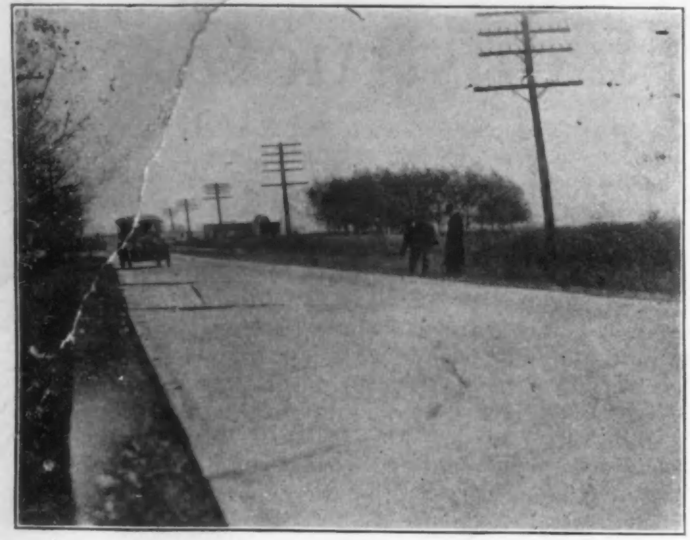


Fig. 3

crushing bearing value of the concrete at 3000 lb. per sq. in. is able to carry the load, but the bearing value for many subsoils is not.

Bearing Value of Soils

From a standpoint of furnishing foundations for buildings, which are static loads instead of being vibratory, the bearing values of soils are rarely ever estimated for more than 5000 lb. or 2½ tons per sq. ft. for the best types of soil. For vibratory loads, such as the sub-bases of hard roads, an average bearing should not be taken at more than 1 ton or 2000 lb. per sq. ft. With the same soils and bad weather conditions 1000 lb. per sq. ft., or less, is all that the soil will stand. The moisture variations in sub-base soils for roads make bearing values appear fickle indeed, ranging from 2 to 10 lb. per sq. in. in some tests made on an Illinois road sub-base and thus ranging from 288 to 1440 lb. per sq. ft., so, the bearing value is illusive and is not safe at over 1000 lb. or less per sq. ft. in Illinois.

Solid rubber tires are rated to carry 800 to 900 lb. per lineal inch of width of tire, on the largest sizes. A 14-in. tire bearing 900 lb. per in. amounts to a total load of 12,600 lb., or 6½ tons under a single wheel. The heaviest makes of large trucks that are actually used often exceed that bearing load per wheel. This tire load of 12,600 lb., disregarding the excess often met with, must be supported by the sub-base of the roadway at the worst season of the year. This is when the ground is wet and the frost is coming out, a time that the sub-base should not be required to support a load of over 2000 lb. per sq. ft., or less; so, to take care of this 12,600 lb. on that wheel, the concrete slab should be able to distribute it over an area of at least 6 sq. ft.

Fig 4

If the wheel gets near the edge of the slab of the concrete, it amounts to making the slab transmit the load in a semi-circular area having a radius of 4 ft. On crossing an expansion joint or cross crack, the wheel load will then be carried, as it were, by the point or apex of a triangular section, making the concrete slab distribute its load from a point or apex of a right-angle corner over the area of 6 sq. ft. already mentioned, which would result in a right-angle triangle, or its equivalent of about 3½ sq. ft. on the side. Assuming that there is underneath this triangular slab a soil bearing of 2000 lb. per sq. ft., there will result strains along the hypothenuse side of this triangle on the extreme fibers of the concrete in tension of 380 lb. per sq. in. for 6½-in. slab and 250 lb. per sq. in. for 8-in. slab. At a soil bearing of 1000 lb. per sq. ft., the better average for bad weather conditions of subsoil, the maximum fiber stress for 6½-in. slab is about 600 lb. per sq. in. and for an 8-in. slab 400 lb. per sq. in. No concrete which is not reinforced will withstand these stresses. Good concrete in tension runs from 250 to 300 lb. per sq. in. Many slabs are seated so that there is a slight movement or vibration of the slab at every load that passes and, with heavy loads, this vibration packs down the subsoil until there is an actual void for a considerable distance underneath the slab. The slab then breaks and this is what occurs in most of the failures. The photographs shown in Figs. 1 to 4 are typical of just such breaks, which in our district have furnished the bulk of the failures in concrete roadways, and Table 1, in connection with Fig. 5, shows the stresses involved as already described.

Correcting Road Failures

Many different remedies have been offered for correcting road failures. One of them is that on clay or aluvial-soil sub-bases there should be placed a cushion 3 or 4 in. thick, of porous material such as sand or cinders, that will permit the sub-base to drain out and remain in a more uniform condition under the varying weather conditions. In some localities the sand sub-base seems to indicate that this is the correct thing to do. In Illinois, however, we have roads that have sand sub-bases that have cracked as badly after a time as the other bases did. It is my opinion that the cost of this sand should be expended in providing a thicker slab of concrete. A sand sub-base 3 in. thick might cost approximately the same as another inch in depth of concrete slab.

If the concrete slab is 6 in. thick and the sand base 3 in., by leaving off the sand base we might make the slab 7 in. The relative beam strength of the concrete slabs would then appear as 36 for the 6-in. and 49 for the 7-in. slab, a gain in strength for the 7-in. slab of one-third, measured in the value of a 6-in. slab. A slab 8 in. thick would represent a beam strength of 64 compared with a beam strength of 81 for a 9-in. slab. Here again more than a one-quarter increase in strength is obtained by an extra 1 in. of depth. In some instances

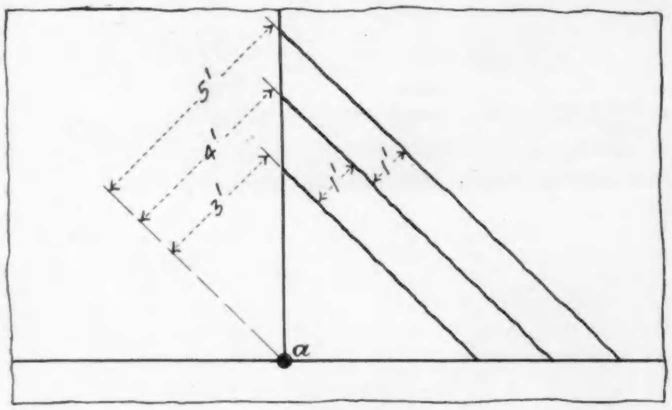


Fig. 5

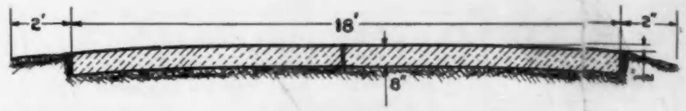


Fig. 8

block before mentioned that is the best form in my opinion.

Fig. 7 represents a typical 8-in. concrete-slab road as now built. A better road, in my opinion, is shown in Fig. 8, where the slab is divided along the middle of the road to let each side spring by itself under heavy loads. Fig. 9 shows the provision for one longitudinal central drain, cared for by cross-drains at intervals. This is better construction than two side-drains. Fig. 10 is better construction than that shown in Figs. 7 and 8, for it allows a central moistening of the sub-base as well as at the sides and provides for uniform settlement of each side slab. Fig. 11 is a suggestion for a steel-surface road having flat steel wheel-tracks 18 in. wide, imbedded in concrete slabs. The steel tracks are inverted channels and the concrete slabs are narrow and ballasted with broken stone, which permits the slabs to be surfaced up like a railroad track. The cost of this appears prohibitive, but one cannot tell what experience

Table 1—Loads and Stresses on Triangular Concrete Slabs[2]

			Pressure between Concrete and Subsoil			
			None		1,000 lb. per sq. ft.[3]	2,000 lb. per sq. ft.[3]
Load at a, Fig. 5, lb.	Length of Arm, ft.	Concrete Thickness, in.	Stress, lb. per sq. in.	Deflection, in.	Stress, lb. per sq. in.	Stress, lb. per sq. in.
9,600	3	6.5	680	0.054	468.0	2.56
	4	6.5	680	0.097	302.0	[4]
	5	6.5	680	0.151	90.0	[4]
	3	8.0	450	0.029	310.0	170
	4	8.0	450	0.052	200.0	[4]
	5	8.0	450	0.081	59.5	[4]
12,600	3	6.5	895	0.071	682.0	380
	4	6.5	895	0.127	516.0	[4]
	5	6.5	895	0.198	302.0	[4]
	3	8.0	590	0.038	450.0	250
	4	8.0	590	0.068	340.0	[4]
	5	8.0	590	0.106	200.0	[4]

[2]Modulus of elasticity equals 2,500,000 lb.
[3]Assuming that no deflection is necessary to obtain the 1000 lb. per sq. ft. pressure, the bending moment for 1000 lb. and for 2000 lb. per sq. ft. pressure between the concrete and the subsoil is reduced an amount equivalent to a load of 1000 lb. or 2,000 lb. per sq. ft. on the concrete, as the case may be, over that under the heading "None."
[4]Concrete at 2000 lb. per sq. ft. pressure would carry the load.

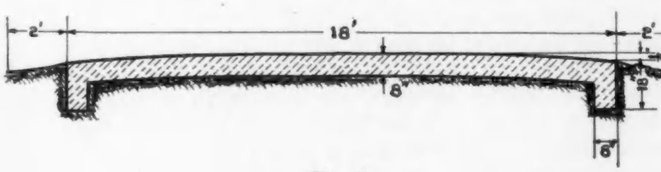


Fig. 6

it is desirable to make the slab on the edges with a rib or a curb section extending down into the soil to stiffen the edges of the slab and shut out the excess moisture that runs over, seeps down under the base and softens the soil sub-base. This edge or under supporting curb block, when made an integral part of the slab itself, is a good investment in many cases. This feature is worthy of consideration for general adoption. It is illustrated in Fig. 6, which shows the side integral curb

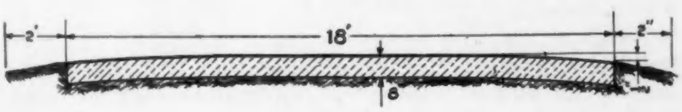
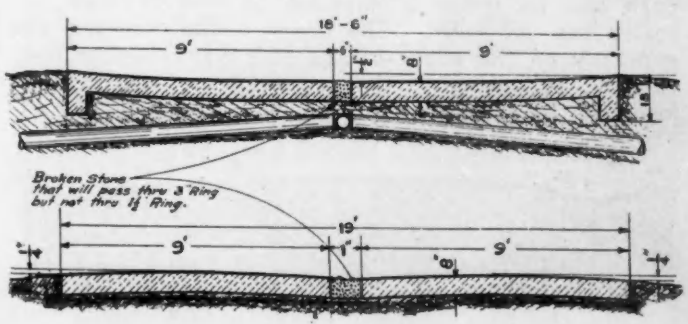


Fig. 7



Figs. 9 and 10

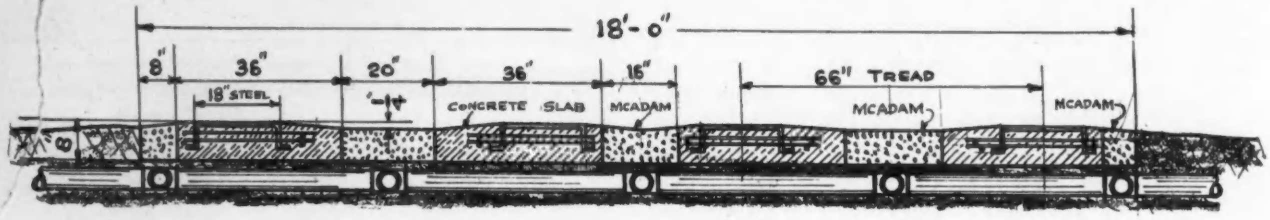


FIG. 11

may lead to. Fig. 12 shows the trend of thought toward a steel-surface road.

Reinforcement

Reinforcing with steel in a concrete road slab is of doubtful value, except in special cases. If reinforcement is applied only sparingly it is of little or no value; in fact, I think it results in injury to the concrete. Reinforcing should be omitted unless sufficient steel is put in the top and bottom of the slab to permit the reinforcing to carry the load at low metal-fiber stresses, so that the stretch of the reinforcing under the maximum fiber stresses will not exceed the elastic limit of the concrete. If, however, the reinforcing is strained up to permissible limits for the steel, the stretch in the steel before those limits are reached breaks the reinforcing free of its bond in the concrete and the latter will crack.

There are certain places where it is well known in advance that the concrete slab will be required to act as a beam; for example, where an embankment is merged onto a solid abutment and it is certain that the soil or sub-base underneath the slab will sag away from the solid abutment. Reinforcing should be placed then on the bottom side of the slab, making this last slab a bridge from the mudbank to the solid masonry abutment. In such cases sufficient reinforcing can be used to make this slab safe. The cost of reinforcing, no matter how sparingly it is used in a road slab, can be better expended generally in providing a deeper concrete slab. Thus, the benefit of the square of the depth in the increased depth of the slab is obtained, making a better road than is obtained for the same money with reinforcing. Working this out in figures of cost and strength of slab will show that this conclusion is correct.

The Ultimate Highway

A concrete-slab road, about 8 in. thick and of a uniform depth across the road, perhaps with an increased thickness integral supporting curb-block on the edges in some locations, is the type of road that should be built in this country. If this road will not stand up, and it appears that it will not carry the maximum strains required by the heaviest trucks, then those heavy trucks must be denied the use of the roads. By roads, I mean country roads. The city pavements are in a different situation, because they extend from curb to curb and no water is expected to seep through and soften the sub-bases. The heavy traffic does not run generally on the edges of the slab but over the body thereof; so, owing to the protected sub-base, heavier loads can be carried on city pavements than can be expected to be carried on a country road. The needs of the automobile world and the general welfare of the country are that we should have the greatest amount of hard roads possible, to be obtained in the shortest space of time and with the least expense. It is better for the roads to be limited to the use of vehicles that will not break down the average standard road than to be required to build a road for our excessively heavy trucks.

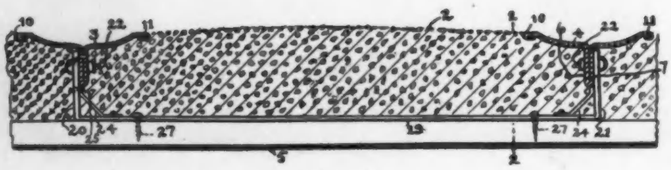


FIG. 12

When a road is built for the maximum load that the heaviest trucks are known to carry, then we will have limited to only a small mileage the ability of the country to furnish that type of road; whereas, with the other types of road, the mileage can be increased so that it will increase the use of automotive vehicles and furnish the demand for vehicles that the manufacturers want, even if in a few instances there is some hardship to the builders of some types of vehicle. In my opinion, the automobile vehicle world will profit by laws that prohibit anything above a 5-ton load and force trailers to take care of the heavy-weight loads. The maximum tire load of the maximum truck load is the factor to be considered, and not the weight per inch of tire. The concrete surface will withstand more per inch than will any rubber tire. It is the beam strength of the concrete slab that counts. In other words, the amount of load per square foot of area on the sub-base which the slab must distribute is what we have to look after.

Impact

Impact is much discussed and is likewise misunderstood. If the road and the tires are smooth and the road has no offsets, the greater the speed of the load over the road is, the less the damage will be. Gravity is a time factor. We remember that as boys we skated over thin ice. A speed of 10 m.p.h. is 14.66 ft. per sec.; at 20 m.p.h. it is 29.33 ft. per sec. Thus the force of gravity on the slab for a given second at 10 m.p.h. is spent on 14.66 ft. of length of the slab and at 20 m.p.h. on 29.33 ft.; so, with smooth surfaces, the speed is a secondary factor of destruction. With bumps in the road, tire speed is a serious factor of destruction. A brick surface cannot be commercially laid without having an infinite number of small offsets that produce impact remaining in its surface.

A speed of 10 m.p.h. is about 1/15 sec. and one of 20 m.p.h. about 1/30 sec. to 1 ft. of travel on the road. The acceleration of gravity will cause a drop of 0.87 in. in 1/15 sec. and 0.22 in. in 1/13 sec. Omitting the action of the springs, a wheel will travel downward off of an abrupt shoulder less than 1 in. in 1 ft. of road travel at 10 m.p.h. and less than ¼ in. at 20 m.p.h. However, the springs of a vehicle counteract this and produce impact of the wheels on the road in much shorter distances. Offsets of any kind are serious factors of impact and destruction.

I repeat that the money available should be made to build the greatest mileage of road that will induce the use of the largest number of automotive vehicles, even at the sacrifice of the heaviest ones.

Chassis Design for Fuel Economy

By A. L. Putnam[1]

Annual Meeting Paper

As the engine is the most important unit of a complete automobile chassis, it has had a major share of attention in its development and it is considerably in advance of the rest of the machine as a result. This is true, notwithstanding the fact that great improvements in engine efficiency are not very evident when the engines are operated under normal conditions of service.

A 10 per cent more efficient engine placed in a motor boat, airplane or tractor is quite likely to preserve that characteristic, but in a passenger-car chassis it may be no better or even 10 per cent worse due to the wide variation of handling speed and load. All engines are now so good and reliable and require so little attention that a man looking after a car and attempting to keep it in condition for smooth operation spends hours on the other parts and units for every minute he spends on the engine. Also, when the car is put into service on the road, nearly all the attention of the driver and passengers is concentrated on the purely vehicular performance of the car with relation to the wide variety of road surfaces, and not on the engine performance. Consequently, for the passenger-car engineer, at any rate, improvements in the automobile as a road vehicle offer greater scope and reward than improvements in engines, particularly as all such improvements are reflected in direct proportion instead of being minimized by a score of adverse operating conditions.

Heavy Greases

The attitude has been common of not worrying about a fraction of 1 per cent loss here and there when such an enormous loss is pouring out of the exhaust pipe and radiator. These other varying and intermittent losses in the aggregate are not insignificant and when multiplied by millions of cars become tens of millions of gallons of fuel and oil. My aim is to call attention to some of them with suggestions as to means and methods of correction. The anti-friction bearings themselves give very little chance for any considerable improvement. But the practice of using a very heavy grease in the transmission and rear axle which solidifies at even a cool temperature from the standpoint of fuel economy and efficient lubrication is far from economical. This is particularly the case when the car is frequently stopped and started and used intermittently in very cold weather. Accurate data can, of course, be secured on this point by driving the transmission or the axle by an electric motor at different temperatures with heavy "dope" or thin engine oil as a lubricant and I am sure the results would be rather informing. The various very good and important reasons which have resulted in the building up of this heavy dope practice have so nearly disappeared that they can all be overcome. It is now perfectly possible to make and install gears which will pass as to sound even if not smothered by dope. It is also possible to construct properly vented transmission cases and differential housings which will hold thin oil with even less leakage than we have at present with the thick.

Dragging Brakes

The great congestion of traffic in cities, towns and in fact almost everywhere has brought about a very common custom of insistence on a brake adjustment which gives instant action with a very small pedal movement. This condition the external-band brake is a very poor instrument to fulfill. It is virtually impossible as a matter of common practice to adjust it closely enough to suit and still not drag some. As the quick brake must be had at any cost, the larger number are dragging. A dragging brake which does not heat enough to call attention to itself by developing excessive heat at a moderate speed still has a marked effect on the position of the throttle and is a very clever scheme to burn gas. Brakes are at this minute, I am sure, pulling from a mere fraction to several horsepower per pair out of the majority of cars equipped with them. The internal-expanding type of brake is much better adapted to extremely close adjustment without dragging and the heat it generates expands and contracts the drum in the right direction with relation to the shoes instead of the wrong direction as in the case of the external-band brake.

You probably all recollect statements which have appeared from time to time in the press by enthusiastic writers that we no longer have horseless carriages but something entirely different and on a much higher mechanical plane than a road vehicle. I have implicitly believed this; I was undeceived this summer in Cincinnati. The company there which transports passengers from one railroad station to the other is not yet fully motorized. It has some light motor buses and some horse-drawn buses which operate at equivalent speed over a vile series of Belgian-block-paved streets. I made the trip one way in a motor bus and the other in the horse-drawn bus. The trip in the latter was so much more smooth and comfortable even with its steel tires and freedom from the bumping, pitching, and sidesway that the pneumatic-tired motor bus had, that after alighting I compared the two vehicles and their construction. This inspection convinced me that we had stuck pretty closely to the old horse carriage and were using all its old stuff with a few extras of our own added for good measure.

Relative Motion of Parts

The main extra the automobile has incorporated is really an extra vehicle. There is one vehicle consisting of wheels, axles, springs, torque-rods, truss-rod, etc., disposed so as to permit of the maximum amount of displacement or separation from the engine frame and body. This engine is asked to transmit its power smoothly and quietly to the wheels and axles which are constantly trying to escape from it and at times taking a very considerable degree of variation in position with relation to it. All these vagaries the engine is asked to furnish the power to produce and it takes some power to lift a 2000-lb. body and load 3 in. up and 4 in. down from the nor-

[1] M.S.A.E.—Research engineer, Detroit Pressed Steel Co., Detroit.

mal position and keep on doing it. Just hitch up an engine on the rear end and let it do that one job only. I am sure the power required is sufficient to measure. It was found out centuries ago that horses could not do it and do anything else. Because we have a source of power that does not sweat and lather is not a reason we should continue present practice.

The excessive amount of motion between the engine and the axle, of course, causes a loss of power and fuel in a minor degree due to joint angularity which produces wear; it takes power to produce wear. I think that this excessive amount of movement, no matter how smoothly accomplished, is not, strictly speaking, a comfortable one for the passengers, and know that it is very fatiguing for the driver, increasing greatly the strain of guiding the vehicle.

We have all probably noticed the small power trip-hammers with the hammer mounted on a leather strap that is shackled to a semi-elliptic spring and the whole head moved up and down by a crank. We have also noticed how the hammer keeps on striking energetically long after the crank has ceased to move it. This trip-hammer is a very good illustration of the action of the axles and springs under the modern automobile and the powerful reactions they give; the engine producing these reactions by furnishing the power to roll over the uneven road surface.

As the weight of the parts in question is on the average about one-quarter of the total weight, they are able to cause considerable disturbance in the smooth operation of the vehicle. This fact is, of course, so generally appreciated that many serious endeavors are made to reduce appreciably the weight of these unsprung parts and by so doing decrease the effect of their action and reaction. These efforts undoubtedly have good effect when they are carried far enough to make an appreciable change in the proportion of sprung and unsprung weight.

Effect of Tire Sizes

No matter what is done to decrease the unsprung weight, the effort starts with a fundamental handicap due to a certain other series of standards. This was called very forcefully to my attention by the declaration of the Tire and Rim Association that the 3½, 4, 4½ and 5-in. tires cover adequately the passenger-car field. This is true no doubt in a narrow sense, but from the standpoint of fuel economy and vehicle efficiency is the pneumatic tire doing all it possibly can? The pneumatic tire is one of the main factors in the success of the passenger automobile. If this tire is such a good thing, why not have a little more of it? Why not give it a larger opportunity to show its worth and itself absorb a larger proportion of the shocks, and give better traction?

Years ago the taximeters came off the rear wheels by law because the rear wheels could accumulate mileage at an astonishing rate. They, of course, use fuel to do it; all rear tires are making much more mileage than the vehicle on some classes of roads and there are thousands and thousands of miles of such roads on which the skipping and spinning is so marked as to affect the throttle position for a certain speed enough to call this to the attention of a not very observing driver. This condition is wasteful of fuel and of the rubber tread as well. The main factor in producing this loss of traction and violent action and reaction on the unsprung weight is the proportional tire cross-sectional size and accompanying air pressure for a given load.

The necessary high air pressure to support the load without injurious deflection of the tire makes the tire so hard and produces such violent reaction when hitting inequalities in the road that the spinning and chattering of the rear tires constitute on many classes of road a very large item of fuel loss, tire destruction and speed. The exceedingly hard small tire is also the instigator of the use of the complicated heavy and highly flexible spring suspension. Given a series of tires of the same outside diameters but considerably increased cross-section for the same load, the air pressure can be cut down safely and a condition produced in which a larger proportion of shocks is absorbed at the source, less slipping and spinning of wheels occur and better traction for starting, running and braking without putting the spring suspension into play so much, is secured.

In fact it is perfectly possible to carry this idea far enough to eliminate the springs entirely and simply provide for the horizontal displacement of the front wheels with relation to the rear pair. When this is done the unsprung weight factor will have disappeared, as all the weight is sprung weight and completely tied together without movement. The wheels move with the body and the body with the wheels.

At present we seem to be accepting as gospel the statement that the present tire sizes as put forward are the last word as regards pneumatic-tire equipment, when a little thought and even less science can prove them as only the beginning of the real use of pneumatic tires.

HECTER AND AVIATION GASOLINE COMPARED

THE National Advisory Committee for Aeronautics, Washington, has issued Report No. 90 containing a comparison of hecter fuel with export aviation gasoline. This fuel is one which has been developed in response to the demand for fuels that are capable of operating under compressions which are too high for gasoline. This fuel will operate at compression ratios up to at least 8.0 without preignition or "pinking." The hecter fuel supplied by the Bureau of Mines for use in these tests was a mixture of 30 per cent benzol and 70 per cent cyclohexane having a low freezing point and distilling from the first drop to 90 per cent at practically a constant temperature that was about 20 deg. cent. (68 deg. fahr.) below the average distillation temperature of the export aviation gasoline with which it was compared.

The comparison of the performance of the two fuels embodied in the report was made with a Liberty 12-cylinder aviation engine supplied with special pistons giving a compression ratio of 7.2 to 1, the compression pressure measured by check-valve gage being 170 lb. per sq. in., in the altitude chamber at the Bureau of Standards, Washington, duplicating altitude conditions up to about 25,000 ft. except that the temperature of the air entering the carbureter was maintained nearly constant at about 10 deg. cent. (50 deg. fahr.). Stromberg carbureters were used and were adjusted for each change of fuel, speed, load and altitude so as to give the maximum possible power with the least fuel consumption for this power. The tests covered a speed range of 1400 to 1800 r.p.m. and the results of these experiments, a preliminary account of which was published in the July, 1920 issue of THE JOURNAL on page 110, show that the power developed by hecter fuel is the same as that developed by export aviation gasoline at approximately 1800 r.p.m. at all altitudes.

A copy of the report can be obtained upon request from the National Advisory Committee for Aeronautics, Washington.

Standards Committee Meeting

THE meeting of the Standards Committee was convened on the morning of Jan. 11 in the Engineering Societies Building, New York City, with Chairman B. B. Bachman presiding. After declaring a quorum present, Chairman Bachman addressed the meeting substantially as follows:

The printed pamphlets that were mailed to the members of the Standards Committee and the Society contain the reports of 12 Divisions of the Standards Committee on 35 subjects completed by the several Divisions since the meeting held at Ottawa Beach, Michigan, last June.

I think that everyone who has taken part in the Standards Committee work thoroughly appreciates its importance. Those who have not taken part in this work meet certain conditions from time to time in the conduct of their business that indicate the necessity for standardization. Probably they have never thought of it before, and it is a customary human failing not to do so until one is forced to meet a difficult situation. Frequently it is not until then that the value of or necessity for standards is appreciated. There are several ways in which the work of the Standards Committee can be enhanced. I think that in general the work of the Divisions is excellent; the meetings are fairly well attended, the amount of thought that is brought to bear on the reports is adequate in most cases, but unfortunately in many instances it stops at that point. The Divisions' recommendations are sent to the Standards Department of the Society where they are tabulated, checked and typographical and other errors corrected so far as possible, but the Standards Department cannot be expected to check matters a knowledge of which is obtained only by experience.

The Divisions' Reports are then submitted to the Standards Committee and usually there are matters of sufficient importance to a large enough number of members to result in discussion being had, but unfortunately a considerable amount of our work is done without sufficient attention being given to it at the Division and Standards Committee meetings.

Immediately following the Standards Committee Meeting, the Divisions' Reports are submitted to the Council and are considered only as a formality in most instances. From time to time, however, subjects come up which the Council deems it wise to refer back to Division for reasons of policy. The Council has never taken the position of acting as an arbitrary body in any sense in connection with the work of the Standards Committee and I think this policy will not be changed.

Presentation of Standards Committee reports to the Society in meeting assembled has become in later years largely a perfunctory matter; the business sessions in connection with which these reports are made are filled with important work, the time is limited and the attendance is relatively small. As a result, the reports have usually been presented by title only by the Chairman of the Standards Committee, and little or no time has been taken for discussion of them. I do not know that this can be changed, by reason of conditions such as I have outlined.

To remedy this condition as much as possible we have in recent years adopted a policy of submitting the proposed standards for letter ballot of the voting members of the Society but unfortunately the returns of these letter ballots are relatively small, amounting to a maximum of some 10 or 12 per cent. Still, after subjects have been approved and adopted, it has been found in a number of instances that things have been done which in the minds of some of our members should not have been done, and in many instances they have had good reasons for so thinking. The trouble has been that they did not take the proper steps at the proper time to have the proposed standards as complete or practical as desirable.

The reason for referring to this matter now is that I desire to appeal to all the members of the Standards Committee who appreciate the importance of its work and to urge them to act as missionaries among their acquaintances in the industry and the membership of the Society to see that the report submitted for letter ballot, as it appears in THE JOURNAL of the Society after it has been passed upon by the Standards Committee and Council, receives adequate consideration and attention by those who are qualified to pass on it and by those who are interested in any of the recommendations that are proposed for adoption. There is no other one thing that I know of that can be done by the members of the Standards Committee that will enhance the work of the Society more than this in one of its most important activities.

The reports as submitted by the several Divisions were presented by the Division Chairmen, and are here given in the form approved by the Standards Committee and the Council.

AERONAUTIC DIVISION REPORT

(1) *Turnbuckles*

During the period of the war the Society, in cooperation with the Bureau of Aircraft Production and the Navy Department, developed and adopted the present S.A.E. Recommended Practice for Aeronautic Turnbuckles printed on pages 45u to 45uj, S.A.E. HANDBOOK, Vol. I (old edition). The Bureau of Aircraft Production, specification No. 25,500, which corresponded with the S.A.E. Recommended Practice, was subsequently changed somewhat by adding the 800 lb. size and more complete tolerances for all sizes, as given in the latest B.A.P.

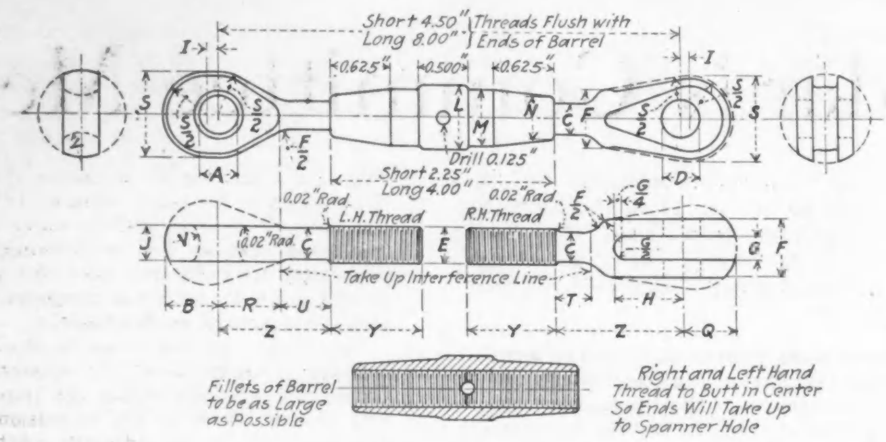
THREAD AND BARREL DIMENSIONS

S.A.E. Size	Threads	Shank Pitch Diameter In.		Barrel Pitch Diameter In.		Barrel			Strength in Pounds
		Max.	Min.	Max.	Min.	L +0.005 −0.005	M +0.005 −0.005	N +0.005 −0.005	
8	6-40	0.1228	0.1211	0.1235	0.1218	0.250	0.219	0.188	800
16	10-32	0.1707	0.1688	0.1716	0.1697	0.375	0.281	0.250	1600
21	12-28	0.1938	0.1918	0.1948	0.1928	0.375	0.328	0.281	2100
32	1/4-28	0.2278	0.2258	0.2288	0.2268	0.438	0.391	0.328	3200
46	5/16-24	0.2864	0.2843	0.2875	0.2854	0.500	0.438	0.406	4600
61	3/8-24	0.3489	0.3468	0.3500	0.3479	0.625	0.594	0.469	6100
80	3/8-24	0.3489	0.3468	0.3500	0.3479	0.625	0.594	0.469	8000

All dimensions in inches.

specification No. 25,500-B, issued Jan. 25, 1919. The B.A.P. specification is more complete and is believed to be more generally followed in production.

Materials.—Barrels shall be made of brass in accord-



TURNBUCKLE DIMENSIONS

S. A. E. Size[1]	Threads	Eye and Fork Ends C +.006 −.000	E	I +.010 −.000	S +.010 −.010	Y +.047 −.047	Z +.031 −.015	Eye End A +.010 −.000	B +.010 −.010	J +.010 −.010	R +.010 −.010	V +.010 −.010	Fork End D +.010 −.000	F +.010 −.005	G +.010 −.000	H +.010 −.010	Q +.010 −.010	T +.005 −.000
8 SF	6-40	.094	.138	.031	.375	.375	1.125	.188	.219	.125	.250	.094	.188	.250	.109	.375	.188	.630
8 SE	6-40	.094	.138	.031	.375	.375	1.125	.188	.219	.125	.250	.094	....	....	....	....	....	....
16 SF	10-32	.133	.190	.031	.500	.500	1.125	.219	.281	.188	.328	.172	.188	.313	.150	.469	.250	.520
16 LF	10-32	.133	.190	.031	.500	.500	2.000	.219	.281	.188	.328	.172	.188	.313	.150	.469	.250	1.385
16 SE	10-32	.133	.190	.031	.500	.500	1.125	.219	281	.188	.328	.172	....	....	....	....	....	....
16 LE	10-32	.133	.190	.031	.500	.500	2.000	.219	.281	.188	.328	.172	....	....	....	....	....	....
21 SF	12-28	.155	.216	.031	.500	.563	1.125	.219	.281	.188	.328	.172	.188	.313	.150[A]	.500	.250	.500
21 LF	12-28	.155	.216	.031	.500	.563	2.000	.219	.281	.188	.328	.172	.188	.313	.150[A]	.500	.250	1.375
21 SE	12-28	.155	.216	.031	.500	.563	1.125	.219	.281	.188	.328	.172	....	....	....	....	....	....
21 LE	12-28	.155	.216	.031	.500	.563	2.000	.219	.281	.188	.328	.172	....	....	....	....	....	....
32 SF	¼-28	.189	.250	.047	.625	.625	1.125	.281	.359	.219	.406	.203	.250	.438	.203[B]	.625	.313	.310
32 LF	¼-28	.189	.250	.047	.625	.625	2.000	.281	.359	.219	.406	.203	.250	.438	.203[B]	.625	.313	1.185
32 SE	¼-28	.189	.250	.047	.625	.625	1.125	.281	.359	.219	.406	.203	....	....	....	....	....	....
32 LE	¼-28	.189	.250	.047	.625	.625	2.000	.281	.359	.219	.406	.203	....	....	....	....	....	....
46 SF	5/16-24	.243	.313	.047	.688	.750	1.125	.313	.391	.281	.469	.250	.313	.500	.203	.625	.344	.310
46 LF	5/16-24	.243	.313	.047	.688	.750	2.000	.313	.391	.281	.469	.250	.313	.500	.203	.625	.344	1.185
46 SE	5/16-24	.243	.313	.047	.688	.750	1.125	.313	.391	.281	.469	.250	....	....	....	....	....	....
46 LE	5/16-24	.243	.313	.047	.688	.750	2.000	.313	.391	.281	.469	.250	....	....	....	....	....	....
61 LF	⅜-24	.256	.375	.063	.750	.875	2.000	.344	.438	.281	.500	.313	.375	.563	.203	.750	.375	2.080
61 LE	⅜-24	.256	.375	.063	.750	.875	2.000	.344	.438	.281	.500	.313	....	....	....	....	....	....
80 LF	⅜-24	.306	.375	.063	.875	.875	2.000	.375	.500	.328	.625	.375	.375	.563	.266	.875	.453	1.906
80 LE	⅜-24	.306	.375	.063	.875	.875	2.000	.375	.500	.328	.625	.375	....	....	....	....	....	....

[1]The letters indicate the following: SF, short fork and eye turnbuckle; LF, long fork and eye turnbuckle; SE, short double-eye turnbuckle; LE, long double-eye turnbuckle. When the eye end is used with a pin and clip the "A" dimension should be made equal to the "D" dimension in the fork end and radius "V" should not be used.
[A]Dimension G may be 0.109 with a lug having an ultimate strength of 125,000 lb. per sq. in.
[B]Dimension G may be 0.140 with a lug having an ultimate strength of 125,000 lb. per sq. in.
All threads U. S. Form.

ance with S.A.E. specification No. 73 or an equivalent alloy.

Shanks shall be treated to withstand the test loads specified.

Tests.—At least 2 per cent of all turnbuckles purchased shall be tested, and must withstand the tensile test load specified.

Each turnbuckle shank which meets the tensile test without breaking shall be held in a square-nose vise and bent through an angle of 90 deg., and must neither fail nor crack under this test.

Dimensions and Tolerances.—Turnbuckles shall conform, within the tolerances stated, to the dimensions specified.

Assembly.—Turnbuckles shall be assembled by selecting barrels and shanks to give a fit which will permit turning by hand.

All threads shall be greased and shanks completely screwed into the barrel before plating.

Finish and Inspection.—Unless otherwise specified, turnbuckles shall be copper plated after assembly and before inspection. They shall be thoroughly rinsed after plating to remove all traces of the electrolyte which may be in threads and barrel.

After inspection turnbuckles shall be either greased or coated with transparent lacquer as specified in the order. Turnbuckle shanks shall be thoroughly covered with non-corrosive grease, before shipment.

THE DISCUSSION

H. M. CRANE:—This has been a very quiet year in aeronautics as there has been really no aeronautic activity aside from supplying the Army and Navy. The result is that we are presenting a very short report. The first half of it refers to a simplification of the standard relating to turnbuckles which was adopted during the war.

J. L. HARKNESS:—The sizes recommended go up to an 8000-lb. turnbuckle, which is equivalent to a ¼-in. cable. I think it is only a question of time before it will have to be extended to include cables of larger sizes. We are developing larger machines now and it would be a good idea to have the standard extended to include turnbuckles to take 5/16 and ⅜-in. cables.

CHAIRMAN BACHMAN:—We will see that your suggestion is referred to the Division for attention.

S. TOUR:—I notice that under materials, the report reads, "Barrels shall be made of naval brass or an equivalent alloy." The Non-Ferrous Metals Division's report covers this, calling this alloy Brass Specification No. 73.

MR. CRANE:—This report was based on the Bureau of Aircraft Production's specification and I think it will be better so far as the Society is concerned, in view of the fact that it would make no actual difference, to change this reference to the S.A.E. Specification No. 73. That can be made an amendment to the motion to accept this report.

[A motion to that effect was made and carried.]

(2) *Special Report of the Aeronautic Division on the Regulation of Commercial Air Navigation*

Owing to the importance of outlining a definite program which would be of value in protecting commercial aviation against adverse legislation, the Council of the Society charged the Aeronautic Division some time ago with the preparation of a special report outlining desirable regulations for commercial air navigation.

The subject was referred to the Aeronautic Subdivision on Performance and Testing and a meeting was held at which the following recommendations were adopted:

A system of Federal registration of all aircraft for identification and in addition, licenses for certain specific purposes or uses should be adopted.

All aircraft carrying passengers for any purpose, or goods in commercial service, should be licensed by the Federal authority, which license shall indicate the aircraft licensed has complied with certain minimum requirements as to safety. By passengers is meant any person not a necessary member of the crew.

Any aircraft not coming under the classification in the previous paragraph may be licensed by the Federal authority even though not complying with the safety requirements, but only for restricted service with a view to minimizing danger to persons or property on the ground. This is intended to cover experimental and special racing aircraft as well as privately owned aircraft not used in commercial or Government service.

Minimum requirements cannot, even as regards the structural strength, be reduced to rules and figures capable of application in inspection except by persons of adequate engineering training in this field, and other necessary minimum requirements regarding safety of operation are the result of compromise and can be applied only by persons with trained judgment.

Any definite requirements or figures should not be written into legislation at this time, because these matters would be handled best by the regulation and ruling of the Federal authority which should be created by legislation.

Aircraft, which, in accordance with previous paragraphs, require a license, should be periodically inspected to insure that they continue to be in a safe operating condition.

MR. CRANE:—The remainder of the report of the Aeronautic Division is the result of very serious consideration by the Subdivision on Performance and Testing regarding the attitude the Society should take, either through this Division or in some other way, regarding restrictions on the operation of aircraft. You all realize that there will be eventually and probably soon legislation determining what are and what are not safe forms of aircraft for use in commercial pursuits. Many of those limitations will be of an engineering character and certainly constitute a subject of importance for consideration by the Society. The Subdivision did not feel that it had had time, or that the time has arrived, to go into all the details of so-called factors of safety and methods of test. It did feel, however, that the best opinion of the Subdivision regarding the methods of applying such tests and restrictions to machines of an experimental nature should be put before the Society. In other words, it is highly important to the Society, which wishes to encourage the development of experimental machines, that no legislation shall put too heavy restrictions on the flying of machines that have not been approved as being entirely safe, provided the tests are made by men who understand, in applying the tests, the risks they are taking.

We believe it is essential that the Society should back Federal legislation with all its strength as against State legislation.

> All aircraft carrying passengers for any purpose, or goods in commercial service, should be licensed by the Federal authority, which license shall indicate the aircraft licensed has complied with certain minimum requirements as to safety. By passengers is meant any person not a necessary member of the crew.

This is to safeguard the experimental machine in which the pilot may take up with him a mechanic or observer who is in the service of the designer and taking a risk which he thoroughly understands.

> Any aircraft not coming under the classification in the previous paragraph may be licensed by the Federal authority even though not complying with the safety requirements, but only for restricted service with a view to minimizing danger to persons or property on the ground. This is intended to cover experimental and special racing aircraft as well as privately owned aircraft not used in commercial or Government service.

This paragraph is plainly for the purpose of safeguarding experimental work and at the same time preventing the flying of experimental and possibly dangerous machines over thickly inhabited areas such as cities or towns, or any places of assembling.

> Minimum requirements cannot, even as regards the structural strength, be reduced to rules and figures capable of application in inspection except by persons of adequate engineering training in this field, and other necessary minimum requirements regarding safety of operation are the result of compromise and can be applied only by persons with trained judgment.

The Subdivision believes it is highly important to make it plain at this time that the ordinary political appointee cannot be expected to apply any rules that engineers can formulate for the products supplied; that is, when the engineers get together and determine what is a safe form of airplane, the result of their labor cannot be applied by technically untrained people. They must know a great deal more about the subject than in the case of the enforcement of import duties or internal revenue regulations or matters of that kind.

> Any definite requirements or figures should not be written into legislation at this time, because these matters would be handled best by the regulation and ruling of the Federal authority which should be created by legislation.

This paragraph states very clearly its reasons. The best engineering talent at the present time is not sufficiently expert to say what those rules should be, and it is far better that the regulating authorities should be able from time to time to make their own rules, provided such rules are made under the advice of experts.

> Aircraft, which, in accordance with previous paragraphs, require a license, should be periodically inspected to insure that they continue to be in a safe operating condition.

I have gone into this special report rather completely because it is a little out of the line of the regular standards work; in fact, it could hardly be called a Standards Committee report. It does however bring up very important questions that should have the attention of the Society and this is an excellent way of doing it.

This report may be considered as a form of further instructions to the Aeronautic Subdivision on Performance and Testing. There is outlined here a policy along the lines it is proposed to work in formulating any standards regarding performance and testing, and it is desirable to bring the matter before the Society to get approval or disapproval of the general program and policy.

Ball and Roller Bearings Division Report

(3) *Shaft and Housing Fits and Tolerances for Ball Bearings*

In order to obtain uniformity of practice as to shaft and housing fits and tolerances for ball bearings, a Subdivision was appointed to formulate a report to the Division. The recommendation of the Subdivision is based on the practice of grinding shaft-seats which is usually followed by automotive manufacturers and an analysis of the press-fit allowances recommended by manufacturers of ball bearings. This recommendation having met with approval by the Division is submitted for approval and publication as general information only. It is contemplated that should this practice become generally adopted by the industry, the Division will at a future time recommend its adoption as an S.A.E. specification.

The substance of the Division's original recommendation was approved by the Standards Committee and Council, and at the business meeting of the Society but the tables were referred back to the Division to be arranged to show the allowable variation in fit of the bearings on the shafts and in the housings as in the accompanying tables.

ALLOWANCES ON SHAFTS

Inside Diameter of Bearing				Fit on Shaft	
Nominal		Tolerances			
Mm.	In.	Plus	Minus	Tight	Loose
25	0.9843	0.0002	0.0004	0.0009	0.0002
30	1.1181	0.0002	0.0004	0.0009	0.0002
35	1.3780	0.0002	0.0004	0.0009	0.0002
40	1.5748	0.0002	0.0004	0.0009	0.0002
45	1.7717	0.0002	0.0004	0.0009	0.0002
50	1.9685	0.0002	0.0004	0.0009	0.0002
55	2.1654	0.0002	0.0004	0.0009	0.0002
60	2.3622	0.0002	0.0005	0.0010	0.0002
65	2.5591	0.0002	0.0005	0.0010	0.0002
70	2.7559	0.0002	0.0005	0.0010	0.0002
75	2.9528	0.0002	0.0005	0.0010	0.0002
80	3.1496	0.0002	0.0005	0.0010	0.0002
85	3.3465	0.0002	0.0006	0.0011	0.0002
90	3.5433	0.0002	0.0006	0.0011	0.0002
95	3.7402	0.0002	0.0006	0.0011	0.0002
100	3.9370	0.0002	0.0006	0.0011	0.0002
105	4.1339	0.0002	0.0006	0.0011	0.0002
110	4.3307	0.0002	0.0006	0.0011	0.0002
115	4.5276	0.0002	0.0006	0.0011	0.0002
120	4.7244	0.0002	0.0006	0.0011	0.0002
125	4.9213	0.0002	0.0006	0.0011	0.0002
130	5.1181	0.0002	0.0006	0.0011	0.0002
135	5.3150	0.0002	0.0006	0.0011	0.0002
140	5.5118	0.0002	0.0006	0.0011	0.0002
145	5.7087	0.0002	0.0006	0.0011	0.0002
150	5.9055	0.0002	0.0006	0.0011	0.0002
155	6.1024	0.0002	0.0006	0.0011	0.0002
160	6.2992	0.0002	0.0006	0.0011	0.0002
165	6.4961	0.0002	0.0006	0.0011	0.0002
170	6.6929	0.0002	0.0006	0.0011	0.0002
175	6.8898	0.0002	0.0006	0.0011	0.0002
180	7.0866	0.0002	0.0006	0.0011	0.0002
185	7.2835	0.0002	0.0006	0.0011	0.0002
190	7.4803	0.0002	0.0006	0.0011	0.0002
195	7.6772	0.0002	0.0006	0.0011	0.0002
200	7.8740	0.0002	0.0006	0.0011	0.0002
205	8.0709	0.0002	0.0006	0.0011	0.0002

For bearings less than 25 mm. in inside diameter, a press fit of 0.0004 in. should be obtained by selected assembly.

Shaft diameters should be measured with a micrometer.

ALLOWANCES IN HOUSINGS

Outside Diameter of Bearing				Fit in Housing	
Nominal		Tolerances			
Mm.	In.	Plus	Minus	Tight	Loose
30	1.1811	0.0000	0.0005	0.0000	0.0015
32	1.2598	0.0000	0.0005	0.0000	0.0015
35	1.3780	0.0000	0.0005	0.0000	0.0015
37	1.4567	0.0000	0.0005	0.0000	0.0015
40	1.5748	0.0000	0.0005	0.0000	0.0015
42	1.6535	0.0000	0.0005	0.0000	0.0015
47	1.8504	0.0000	0.0005	0.0000	0.0015
52	2.0472	0.0000	0.0008	0.0000	0.0018
62	2.4409	0.0000	0.0008	0.0000	0.0018
72	2.8346	0.0000	0.0008	0.0000	0.0018
80	3.1496	0.0000	0.0008	0.0000	0.0018
85	3.3465	0.0000	0.0008	0.0000	0.0018
90	3.5433	0.0000	0.0008	0.0000	0.0018
100	3.9370	0.0000	0.0008	0.0000	0.0018
110	4.3307	0.0000	0.0008	0.0000	0.0018
120	4.7244	0.0000	0.0008	0.0000	0.0018
125	4.9213	0.0000	0.0008	0.0000	0.0018
130	5.1181	0.0000	0.0008	0.0000	0.0023
140	5.5118	0.0000	0.0008	0.0000	0.0023
150	5.9055	0.0000	0.0012	0.0000	0.0027
160	6.2992	0.0000	0.0012	0.0000	0.0027
170	6.6929	0.0000	0.0012	0.0000	0.0027
180	7.0866	0.0000	0.0012	0.0000	0.0027
190	7.4803	0.0000	0.0012	0.0000	0.0027
200	7.8740	0.0000	0.0012	0.0000	0.0027
210	8.2677	0.0000	0.0012	0.0000	0.0027
215	8.4646	0.0000	0.0012	0.0000	0.0027
220	8.6614	0.0000	0.0012	0.0000	0.0027
225	8.8583	0.0000	0.0012	0.0000	0.0027
230	9.0551	0.0000	0.0012	0.0000	0.0027
240	9.4488	0.0000	0.0012	0.0000	0.0027
250	9.8425	0.0000	0.0012	0.0000	0.0027
260	10.2362	0.0000	0.0012	0.0000	0.0027
265	10.4331	0.0000	0.0012	0.0000	0.0032
270	10.6299	0.0000	0.0012	0.0000	0.0032
280	11.0236	0.0000	0.0012	0.0000	0.0032
290	11.4173	0.0000	0.0012	0.0000	0.0032
300	11.8110	0.0000	0.0012	0.0000	0.0032
310	12.2047	0.0000	0.0012	0.0000	0.0032
320	12.5984	0.0000	0.0012	0.0000	0.0032
330	12.9921	0.0000	0.0012	0.0000	0.0032
340	13.3858	0.0000	0.0012	0.0000	0.0032
350	13.7795	0.0000	0.0012	0.0000	0.0032
360	14.1732	0.0000	0.0012	0.0000	0.0032
370	14.5669	0.0000	0.0012	0.0000	0.0032
380	14.9606	0.0000	0.0012	0.0000	0.0032
390	15.3543	0.0000	0.0012	0.0000	0.0032
400	15.7480	0.0000	0.0012		

Housing bores should be measured with a plug gage.

THE DISCUSSION

MR. CRANE:—I think that it would be of considerable advantage if the information given in these tables was in a little different form. Any one who has had experience with machine work knows that shaft tolerances of plus 0.0005 and minus 0.0000 in. are out of the question; for instance, an axle company would not furnish axles to dimensions based on these tolerances.

W. R. STRICKLAND:—I might mention that these fits are based on grinding fits. The reason the shaft and housing sizes were given as they are was so that manufacturers who want to work more closely than this can do so and as a matter of fact, when they grind to the dimensions given, 75 per cent of the sizes will be within a couple ten-thousandths of the figures given.

EARLE BUCKINGHAM:—The outside diameters of the bearings, for example, a 200 millimeter size, are given a tolerance of 0.0012 (and this is a ground fit), while just half a thousandth is given on the shaft. A half thousandth could be held on the smaller diameters, but I fail to see how the larger diameters could be measured and checked accurately in production to that half thousandth fit without extremely accurate measuring instruments. A micrometer would never do it.

MR. CRANE:—The tables, as I understand them, are simply a reproduction of the already accepted standard

tolerances on ball bearings. The Division feels that it is desirable that certain limits of fit should be used in fitting bearings on shafts; that they should never be more than a certain amount tight nor a certain amount loose to be a passable fit. My object in suggesting the change is to leave to the manufacturer of the shafts the matter of how he shall obtain that fit. He would set his own limits on the diameter of the shaft or housing to meet what he considers correct fits.

F. W. GURNEY:—What the Division has tried to do is to give some tolerances and allowances which can be met, although as a matter of actual practice perhaps they would not be met in the majority of cases. The only way to get the fits that are desired in the great majority of cases is by selective fitting, but in some instances where such fits cannot be afforded, a fit all the way from 0.0002 in. loose to 0.0009 in. tight can be endured. In cases where such practice will not do, the only way to get along is to make selective fits, unless bearings specially selected to give narrower limits than the adopted S.A.E. Standards are requested.

(4) *Annular Ball Bearings—Separable (Open) Type*

The Ball and Roller Bearings Division recommends that the present S.A.E. Standard for Separable (Open) Type Annular Ball Bearings, page C32, S.A.E. HANDBOOK, Vol. I. (new edition), be revised as follows:

> Change the heading in the column "Width of individual rings" to read "Overall width" and add tolerances of plus or minus 0.002 in. to be placed on the "Overall width."
>
> Add the footnote referring to overall widths, to read "The nominal width of individual rings shall be the same as for the overall widths in the above table but shall have tolerances of plus or minus 0.001 in."

(5) *Annular Ball Bearings—Wide Type*

The Ball and Roller Bearings Division recommends that the present S.A.E. Standard for Extra Wide Type Annular Ball Bearings, page C31; S.A.E. HANDBOOK, Vol. I (new edition), be amplified as follows to make it more complete:

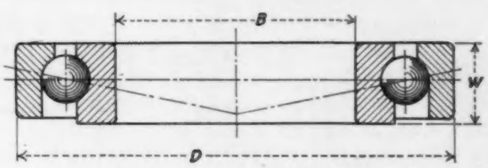
> Change the Sub-title "Extra Wide Type" to read "Wide Type" and add the note, "The bore and outside diameters for wide type annular ball bearings shall be the same as for the corresponding size annular ball bearings in the light, medium and heavy series."
>
> Also add the footnote referring to the title, to read "Normally these bearings are a double-row type of construction."

(6) *Angular Contact Ball Bearings*

The present S.A.E. Standard for Angular Contact Ball Bearings of the light, medium and heavy series is as follows:

> Ball bearings of the angular contact type are identical in size and boundary dimensions with S.A.E. Standard annular ball bearings of the light, medium and heavy series as printed on page C33, S.A.E. HANDBOOK, Vol. I (new edition).

Toward completing the standard for angular contact bearings, consensus of opinion of the Ball and Roller Bearings Division members is that the bore, outside diameter and eccentricity tolerances specified for light, medium



ANGULAR CONTACT TYPE BEARING

and heavy series annular ball bearings be adhered to for the angular contact type, and that the tolerances for the overall widths be specified as in the table, with the footnote reading, "The width tolerances for the individual rings shall be the same as those of the corresponding sizes of annular ball bearings of the light, medium and heavy series." It is also recommended that the angular contact type bearings table be published as separate and

ANGULAR CONTACT BALL BEARINGS—LIGHT SERIES

Bearing Number	Bore			Outside Diameter			Overall Width[2]			Minimum Corner Radius		Eccentricity Tolerances, In.	
	Mm.	In.	Inch Tolerances Plus 0.0002 Minus	Mm.	In.	Inch Tolerances Plus 0.0000 Minus	Mm.	In.	Inch Tolerances Plus or Minus	Mm.	In.	Inner Race	Outer Race
200	10	0.39370	0.0004	30	1.18110	0.0005	9	0.35433	0.003	1	0.04	0.0006	0.0012
201	12	0.47244	0.0004	32	1.25984	0.0005	10	0.39370	0.003	1	0.04	0.0006	0.0012
202	15	0.59055	0.0004	35	1.37795	0.0005	11	0.43307	0.003	1	0.04	0.0006	0.0012
203	17	0.66929	0.0004	40	1.57481	0.0005	12	0.47244	0.003	1	0.04	0.0006	0.0012
204	20	0.78740	0.0004	47	1.85040	0.0005	14	0.55118	0.003	1	0.04	0.0006	0.0012
205	25	0.98425	0.0004	52	2.04725	0.0008	15	0.59055	0.003	1	0.04	0.0008	0.0012
206	30	1.18110	0.0004	62	2.44095	0.0008	16	0.62992	0.003	1	0.04	0.0008	0.0012
207	35	1.37795	0.0004	72	2.83465	0.0008	17	0.66929	0.003	1	0.04	0.0008	0.0012
208	40	1.57481	0.0004	80	3.14962	0.0008	18	0.70866	0.003	2	0.08	0.0008	0.0012
209	45	1.77166	0.0004	85	3.34647	0.0008	19	0.74803	0.003	2	0.08	0.0010	0.0016
210	50	1.96851	0.0004	90	3.54332	0.0008	20	0.78740	0.003	2	0.08	0.0010	0.0016
211	55	2.16536	0.0004	100	3.93702	0.0008	21	0.82677	0.003	2	0.08	0.0010	0.0016
212	60	2.36221	0.0005	110	4.33072	0.0008	22	0.86614	0.003	2	0.08	0.0010	0.0016
213	65	2.55906	0.0005	120	4.72443	0.0008	23	0.90551	0.005	2	0.08	0.0010	0.0016
214	70	2.75591	0.0005	125	4.92128	0.0008	24	0.94488	0.005	2	0.08	0.0010	0.0016
215	75	2.95277	0.0005	130	5.11813	0.0008	25	0.98425	0.005	2	0.08	0.0010	0.0016
216	80	3.14962	0.0005	140	5.51183	0.0008	26	1.02362	0.005	3	0.12	0.0012	0.0018
217	85	3.34647	0.0006	150	5.90554	0.0012	28	1.10236	0.010	3	0.12	0.0012	0.0018
218	90	3.54332	0.0006	160	6.29924	0.0012	30	1.18110	0.010	3	0.12	0.0012	0.0018
219	95	3.74017	0.0006	170	6.69294	0.0012	32	1.25984	0.010	3	0.12	0.0012	0.0018
220	100	3.93702	0.0006	180	7.08664	0.0012	34	1.33858	0.010	3	0.12	0.0012	0.0018
221	105	4.13387	0 0006	190	7.48035	0.0012	36	1.41732	0.010	3	0.12	0.0012	0.0018
222	110	4.33072	0.0006	200	7.87405	0.0012	38	1.49607	0.010	3	0.12	0.0012	0.0018

[2]Width tolerances of individual rings shall be the same as the width tolerances of corresponding sizes of Annular Ball Bearings of the Light, Medium and Heavy Series.

ANGULAR CONTACT BALL BEARINGS—MEDIUM SERIES

Bearing Number	Bore			Outside Diameter			Overall Width[3]			Minimum Corner Radius		Eccentricity Tolerances, In.	
	Mm.	In.	Inch Tolerances Plus 0.0002 Minus	Mm.	In.	Inch Tolerances Plus 0.0000 Minus	Mm.	In.	Inch Tolerances Plus or Minus	Mm.	In.	Inner Race	Outer Race
300	10	0.39370	0.0004	35	1.37795	0.0005	11	0.43307	0.003	1	0.04	0.0006	0.0012
301	12	0.47244	0.0004	37	1.45669	0.0005	12	0.47244	0.003	1	0.04	0.0006	0.0012
302	15	0.59055	0.0004	42	1.65355	0.0005	13	0.51181	0.003	1	0.04	0.0006	0.0012
303	17	0.66929	0.0004	47	1.85040	0.0005	14	0.55118	0.003	1	0.04	0.0006	0.0012
304	20	0.78740	0.0004	52	2.04725	0.0008	15	0.59055	0.003	1	0.04	0.0006	0.0012
305	25	0.98425	0.0004	62	2.44095	0.0008	17	0.66929	0.003	1	0.04	0.0008	0.0012
306	30	1.18110	0.0004	72	2.83465	0.0008	19	0.74803	0,003	2	0.08	0.0008	0.0012
307	35	1.37795	0.0004	80	3.14962	0.0008	21	0.82677	0.003	2	0.08	0.0008	0.0012
308	40	1.57481	0.0004	90	3.54332	0.0008	23	0.90551	0.003	2	0.08	0.0008	0.0012
309	45	1.77166	0.0004	100	3.93702	0.0008	25	0.98425	0.003	2	0.08	0.0010	0.0016
310	50	1.96851	0.0004	110	4.33072	0.0008	27	1.06299	0.003	2	0.08	0.0010	0.0016
311	55	2.16536	0.0004	120	4.72443	0.0008	29	1.14173	0.003	2	0.08	0.0010	0.0016
312	60	2.36221	0.0005	130	5.11813	0.0008	31	1.22047	0.003	2	0.08	0.0010	0.0016
313	65	2.55906	0.0005	140	5.51183	0.0008	33	1.29921	0.005	3	0.12	0.0010	0.0016
314	70	2.75591	0.0005	150	5.90554	0.0012	35	1.37795	0.005	3	0.12	0.0010	0.0016
315	75	2.95277	0.0005	160	6.29924	0.0012	37	1.45669	0.005	3	0.12	0.0010	0.0016
316	80	3.14962	0.0005	170	6.69294	0.0012	39	1.53544	0.005	3	0.12	0.0012	0.0018
317	85	3.34647	0.0006	180	7.08664	0.0012	41	1.61418	0.010	3	0.12	0.0012	0.0018
318	90	3.54332	0.0006	190	7.48035	0.0012	43	1.69292	0.010	3	0.12	0.0012	0.0018
319	95	3.74017	0.0006	200	7.87405	0.0012	45	1.77166	0.010	3	0.12	0.0012	0.0018
320	100	3.93702	0.0006	215	8.46460	0.0012	47	1.85040	0.010	3	0.12	0.0012	0.0018
321	105	4.13387	0.0006	225	8.85830	0.0012	49	1.92914	0.010	3	0.12	0.0012	0.0018
322	110	4.33072	0.0006	240	9.44886	0.0012	50	1.96851	0.010	3	0.12	0.0012	0.0018

[3]Width tolerances of individual rings shall be the same as the width tolerances of corresponding sizes of Annular Ball Bearings of the Light, Medium and Heavy Series.

ANGULAR CONTACT BALL BEARINGS—HEAVY SERIES

Bearing Number	Bore			Outside Diameter			Overall Width[4]			Minimum Corner Radius		Eccentricity Tolerances, In.	
	Mm.	In.	Inch Tolerances Plus 0.0002 Minus	Mm.	In.	Inch Tolerances Plus 0.0000 Minus	Mm.	In.	Inch Tolerances Plus or Minus	Mm.	In.	Inner Race	Outer Race
403	17	0.66929	0 0004	62	2.44095	0.0008	17	0.66929	0.003	1	0.04	0.0006	0.0012
404	20	0.78740	0.0004	72	2.83465	0.0008	19	0.74803	0.003	2	0.08	0.0006	0.0012
405	25	0.98425	0.0004	80	3.14962	0.0008	21	0.82677	0.003	2	0.08	0.0008	0.0012
406	30	1.18110	0.0004	90	3.54332	0.0008	23	0.90551	0.003	2	0.08	0.0008	0.0012
407	35	1.37795	0.0004	100	3.93702	0.0008	25	0.98425	0.003	2	0.08	0.0008	0.0012
408	40	1.57481	0.0004	110	4.33072	0.0008	27	1.06299	0.003	2	0.08	0.0008	0.0012
409	45	1.77166	0.0004	120	4.72443	0.0008	29	1.14173	0.003	2	0.08	0.0010	0.0016
410	50	1.96851	0.0004	130	5.11813	0.0008	31	1.22047	0.003	2	0.08	0.0010	0.0016
411	55	2.16536	0.0004	140	5.51183	0.0008	33	1.29921	0.003	3	0.12	0.0010	0.0016
412	60	2.36221	0.0005	150	5.90554	0.0012	35	1.37795	0.003	3	0.12	0.0010	0.0016
413	65	2.55906	0.0005	160	6.29924	0.0012	37	1.45669	0.005	3	0.12	0.0010	0.0016
414	70	2.75591	0.0005	180	7.08664	0.0012	42	1.65355	0.005	3	0.12	0.0010	0.0016
415	75	2.95277	0.0005	190	7.48035	0.0012	45	1.77166	0.005	3	0.12	0.0010	0.0016
416	80	3.14962	0.0005	200	7.87405	0.0012	48	1.88977	0.005	3	0.12	0.0012	0.0018
417	85	3.34647	0.0006	210	8.26775	0.0012	52	2.04725	0.010	3	0.12	0.0012	0.0018
418	90	3.54332	0.0006	225	8.85830	0.0012	54	2.12599	0.010	3	0.12	0.0012	0.0018
419	95	3.74017	0.0006	250	9.84256	0.0012	55	2.16536	0.010	3	0.12	0.0012	0.0018
420	100	3.93702	0.0006	265	10.43311	0.0012	60	2.36221	0.010	3	0.12	0.0012	0.0018

[4]Width tolerances of individual rings shall be the same as the width tolerances of corresponding sizes of Annular Ball Bearings of the Light, Medium and Heavy Series.

complete standards as in the accompanying tables toward facilitating their use.

The present standard extended to conform to these recommendations is given in the tables on this and the preceding page.

Electric Transportation Division Report

(7) *Electric Vehicle Storage Battery Jars*

The recommendation of the Electric Transportation Division that the present S.A.E. Standard for Electric Vehicle Storage Battery Jars, page B39, S.A.E. Handbook, Vol. 1 (new edition), be revised was amended and approved as given below.

The action of the Division in eliminating the low-rib type of jar is on account of the fact that a more efficient storage battery can be designed with the high-rib type.

Electric Passenger Vehicle Jars. Hard rubber jars shall have a nominal tensile strength of 3000 lb. per sq. in. with a nominal elongation of 5 per cent; a tensile strength of 3600 lb. per sq. in. with an elongation of not less than 3 per cent; an elongation of not less than 6 per cent with a tensile strength of not less than 2700 lb. per sq. in.; and for intermediate values of the tensile strength and the elongation the numerical product of the tensile strength in pounds per square inch and the elongation in percentage shall not be less than 15,000.[5]

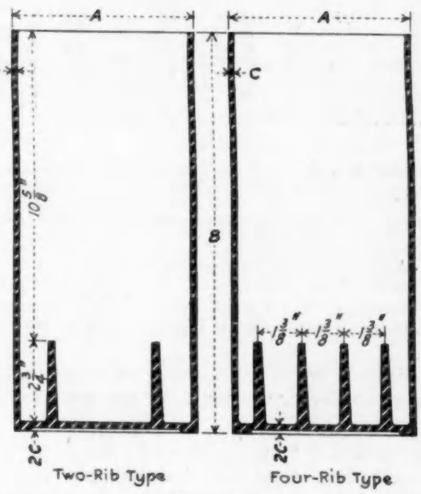
The nominal wall thickness shall be 1/8 in. with tolerances of plus zero and minus 1/64 in.; all types shall have a width of 6 1/8 in., an overall height of 13 5/8 in., a rib height of 2 3/4 in. and a height from the top of the rib to the top of the jar of 10 5/8 in. The number of sizes shall be limited to 15, with the following outside lengths: 2 5/16, 2 1/2, 2 13/16, 3, 3 1/8, 3 5/16, 3 1/2, 3 11/16, 3 13/16, 4, 4 1/4, 4 1/2, 4 13/16, 5 and 5 5/16 in.

[5]This is in accordance with the specification of the Hard Rubber Division of the War Service Commission issued Aug. 28, 1918.

The tolerances for the length, width and height shall be plus or minus 1/32 in.

Jars shall have 2 or 4 ribs; when 4 ribs are used they shall be $1\frac{3}{8}$ in. between centers.

Electric Commercial Vehicle Jars. Hard rubber jars shall have a nominal tensile strength of 5000 lb. per sq. in. with an elongation of 6 per cent; a tensile strength



ELECTRIC VEHICLE STORAGE BATTERY JARS

Class	Overall Width (A)	Overall Height (B) $\pm\frac{1}{32}$	Wall Thickness (C)	Overall Length		Nominal Inside Length
				Nominal	Tolerances	
1	$6\frac{3}{16}$ $+\frac{1}{32}$ $-\frac{3}{64}$	$13\frac{11}{16}$	$\frac{5}{32}$ $+0$ $-\frac{1}{64}$	$2\frac{1}{16}$ $2\frac{9}{16}$ $2\frac{7}{8}$ $3\frac{1}{16}$ $3\frac{9}{16}$ $4\frac{1}{16}$ $4\frac{5}{16}$ $4\frac{7}{8}$ $5\frac{1}{16}$ $5\frac{9}{16}$	$+\frac{1}{32}$ $-\frac{3}{64}$	$1\frac{3}{4}$ $2\frac{1}{4}$ $2\frac{9}{16}$ $2\frac{3}{4}$ $3\frac{1}{4}$ $3\frac{3}{4}$ 4 $4\frac{9}{16}$ $4\frac{3}{4}$ $5\frac{1}{4}$
2	$6\frac{1}{4}$ $\pm\frac{3}{64}$	$13\frac{3}{4}$	$\frac{3}{16}$ $+\frac{1}{128}$ $-\frac{1}{64}$	$5\frac{7}{8}$ $6\frac{1}{8}$ $6\frac{1}{4}$ $6\frac{5}{8}$ $6\frac{7}{8}$ $7\frac{1}{8}$ $7\frac{3}{8}$ $7\frac{1}{2}$ $7\frac{5}{8}$	$\pm\frac{3}{64}$	$5\frac{1}{2}$ $5\frac{3}{4}$ $5\frac{7}{8}$ $6\frac{1}{4}$ $6\frac{1}{2}$ $6\frac{3}{4}$ 7 $7\frac{1}{8}$ $7\frac{1}{4}$
3	$6\frac{1}{4}$ $+\frac{3}{64}$ $-\frac{1}{16}$	$13\frac{3}{4}$	$\frac{3}{16}$ $+\frac{1}{128}$ $-\frac{1}{64}$	$8\frac{1}{8}$ $8\frac{5}{8}$ $8\frac{3}{4}$ $8\frac{7}{8}$ $9\frac{3}{8}$ $9\frac{5}{8}$ 10 $10\frac{3}{8}$	$+\frac{3}{64}$ $-\frac{1}{16}$	$7\frac{3}{4}$ $8\frac{1}{4}$ $8\frac{3}{8}$ $8\frac{1}{2}$ 9 $9\frac{1}{4}$ $9\frac{5}{8}$ 10
4	$6\frac{1}{4}$ $\pm\frac{1}{16}$	$13\frac{3}{4}$	$\frac{3}{16}$ $+\frac{1}{128}$ $-\frac{1}{64}$	$10\frac{5}{8}$ $11\frac{1}{8}$ $11\frac{1}{4}$ $11\frac{7}{8}$ $12\frac{5}{8}$	$\pm\frac{1}{16}$	$10\frac{1}{4}$ $10\frac{3}{4}$ $10\frac{7}{8}$ $11\frac{1}{2}$ $12\frac{1}{4}$

All dimensions in inches.

of not less than 4000 lb. per sq. in. with an elongation of not less than $7\frac{1}{2}$ per cent; an elongation of not less than 5 per cent with a tensile strength of not less than 6000 lb. per sq. in.; and for intermediate values of the tensile strength and the elongation the product of the tensile strength in pounds per square inch and the elongation in percentage shall be not less than 30,000.*

Jars shall have 2 or 4 ribs; when 4 ribs are used they shall be $1\frac{3}{8}$ in. between centers.

*This is in accordance with War Department Specification No. 223-1-38 issued May 1, 1919 for Storage Batteries for Industrial Tractors and Trucks.

This recommendation also applies to industrial truck and tractor storage battery jars.

THE DISCUSSION

W. E. HOLLAND:—We have found that the rubber manufacturers are divided on the use of the dimension shown for two-rib jars. The Division specified $3\frac{1}{2}$ in. but some of the rubber manufacturers are using $3\frac{1}{4}$ in. We have not had time since discovering this to meet with the rubber manufacturers and decide on a compromise. It would mean a great expense to some of them to change all their jar mandrels from $3\frac{1}{4}$ to $3\frac{1}{2}$ in. or vice versa. I therefore recommend that this report be amended to eliminate the $3\frac{1}{2}$-in. dimension on two-rib jars, until we can determine on it at a later date.

BRUCE FORD:—I think Mr. Holland's point is very well taken, inasmuch as this difference exists in the mandrels of the different rubber manufacturers. I think it makes no difference whether that dimension is $3\frac{1}{4}$ or $3\frac{1}{2}$ in. We could eliminate the $3\frac{1}{2}$-in. dimension from the drawing and change the paragraph referring to the rib spacing to read as follows:

> Jars shall have two or four ribs. When four ribs are used, the spacing shall be $1\frac{3}{8}$ in. between centers.

It is important to have the rib spacing match up properly in the four-rib jar, because feet are used, on the plates, but in the two-rib jar feet are not used.

R. W. WOODWARD:—I am not particularly familiar with the testing of hard rubber or materials such as battery jars are composed of, but it seemed to me, in reading these specifications, that there might be some difficulty in meeting them, particularly as to the tensile strength and elongation. We know that a test-specimen means considerable difference in results obtained. It is possible that such a condition exists in testing rubber of this type. I would like to inquire whether the Division has considered that, and whether it is advisable to specify the type of specimens to be used in getting these results.

MR. FORD:—I think the best answer to that is that these specifications are already in existence and have been used by the rubber manufacturers for many years. It would be rather difficult to get any other specification that they would understand and that would be workable. This is practical because it is in operation and has worked satisfactorily.

E. L. CLARK:—I think that the tensile strength and elongation specifications for the jars for commercial vehicles are the same as the Navy Standard. There is a reference note stating that they are the same as the War Department specification of May 1, 1919.

MR. FORD:—There is a slight difference in the wording, but the compound is substantially the same. The matter of tolerances is a little different and I think that the specification as it now stands is better because it is based on the experience resulting from other specifications which were found more or less wanting in some respects.

ELECTRICAL EQUIPMENT DIVISION REPORT

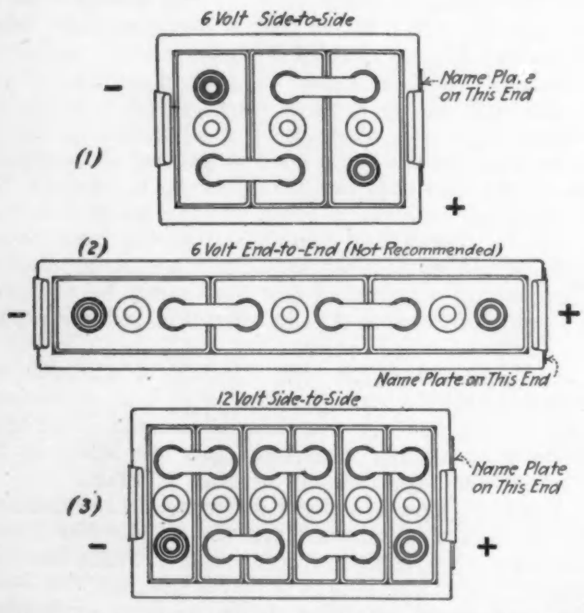
(8) *Storage Batteries*

The Electrical Equipment Division appointed a Subdivision on Storage Batteries in January, 1919, to cooperate with the Bureau of Standards and the Motor Transport Corps in the formulation of specifications for starting and lighting storage batteries for military automobile and motor truck service for the use of the Government, and to revise the present storage battery standards. Several joint meetings, which members of the S.A.E. Subdivision on Storage Batteries, members of

the A.I.E.E. Sub-Committee on Storage Batteries and representatives of the Bureau of Standards, the Navy Department, the Motor Transport Corps, the Automotive Electric Association, and storage battery manufacturers attended, were held. These resulted in the formulation of a specification which was printed in the December 1920 issue of THE JOURNAL.

On the completion of this work the Subdivision gave careful consideration to revising the present S.A.E. Standards for storage battery terminal posts, posts for small cells, storage battery compartments, dimensions of lead batteries for lighting and for combined lighting and starting service, and rating of lead batteries for lighting and for combined lighting and starting service on gasoline automobiles, pages B23 and B24, S.A.E. HANDBOOK, Vol. I (new edition). It was considered advisable to combine these standards under one heading entitled "Lead-Acid Storage Batteries." The complete recommendation was approved as follows:

Ratings—Batteries for combined starting and lighting service shall have two ratings. The first rating shall indicate the lighting ability and shall be the capacity in ampere-hours when the battery is discharged continuously at the 5-hr. rate to a final voltage of not less than 1.7 per cell, the temperature of the battery beginning such discharge being 80 deg. fahr. The second rating shall indicate the starting ability and shall be the capacity in ampere-hours when the battery is discharged continuously at the 20-min. rate to a final voltage of not less than 1.5 per cell, the temperature of the battery beginning such discharge being 80 deg. fahr.



LOCATION OF STORAGE BATTERY TERMINAL POSTS, HANDLES AND NAME PLATES

The location and polarity of the terminal posts and the position of the handles and the name plates shall be as shown in the accompanying illustration.

Terminal Posts—When taper posts are used for terminals of lead-acid storage batteries, the dimensions in inches shall be

Small diameter of the negative post	5/8
Small diameter of the positive post	11/16
Taper per foot	1-1/3
Minimum length of taper	11/16

When straight terminal posts are used, the diameter of both the positive and negative posts shall be 13/16 in. and the minimum clear length of the post shall be 13/16 in.

These dimensions refer to batteries for lighting service as well as for combined starting and lighting service.

Compartments — Compartments for starting and lighting batteries shall be of metal not less than 18 United States plate gage (0.050 in.) in thickness, supported entirely by the chassis.

Battery compartments shall be 8 in. wide and 10⅛ in. high in order to give a ¼-in. clearance all around the battery. End-to-end assembly of jars is not recommended on account of the inherent weakness of this type of construction.

The battery shall rest on two wooden strips each 2 in. wide by ¼-in. thick, running lengthwise of the compartment. These shall be positively spaced with the edges flush with the sides of the battery. Spacers shall be provided to give a ¼-in. space at each side of the battery and a 1½-in. space at each end outside of the hold-down devices.

The compartment shall be drained and ventilated.

The hold-down devices should be attached at the level of the top of the battery, not to the top of the handles.

LEAD-ACID STORAGE BATTERY SIZES AND CAPACITIES

No.	No. of Cells	Minimum Capacity Amp-Hr.		Maximum Overall Dimensions, In.[7]			Fig. No.
		5-hr. rate	20-min. rate	Length	Width	Height	
1	3	60	31	9¾	7½	9⅞	1
2	3	72	37	11⅛	7½	9⅞	1
3	3	84	43	12⅝	7½	9⅞	1
4	3	84	43	20⅝	4¾	9⅞	2[8]
5	3	96	50	13¾	7½	9⅞	1
6	3	95	43	15⅜	7½	9⅞	1
7	3	95	43	20⅝	5⅝	9⅞	2[8]
8	6	36	19	13¼	7½	9⅞	3
9	6	48	25	15⅜	7½	9⅞	3

Dimensions in inches.

[7]The overall length of batteries for starting and lighting service measured from end to end of case includes handles, but not hold-down devices. The space occupied by the handles and the hold-down devices shall be only in the direction of the length of the battery, not in the direction of its width. Terminals and connections shall not extend above the handles; the latter shall be the highest point.

[8]Not recommended.

The principal differences between this report and the standards are as follows:

The report is specifically limited to lead-acid storage batteries in order that the specification will not be applied to Edison storage batteries.

The S.A.E. Recommended Practice for Posts for Small Cells, page B23, S.A.E. HANDBOOK, Vol. I (new edition), is omitted as the battery sizes proposed for adoption do not require the use of small terminal posts.

The compartment height of 10 in. specified in the present S.A.E. Standard for Storage Battery Compartments, page B24, S.A.E. HANDBOOK, Vol. I (new edition), is changed to 10⅛ in.

The present S.A.E. Standard for dimensions of Lead Storage Batteries for Starting and Lighting Service, page B23, S.A.E. HANDBOOK, Vol. I (new edition), is revised to specify a list of the sizes and capacities based on present practice which is considered comprehensive enough for practically all commercial requirements.

The present S.A.E. Standard for Ratings of Lead Storage Batteries for Starting and Lighting Service is revised to conform with acceptable commercial practice.

THE DISCUSSION

R. H. COMBS:—I fail to understand why it is necessary or even advisable to have tapered posts of different sizes

on the positive and negative ends of the battery when the same provision for safety has not been made on the straight post. If it is necessary with a tapered post, and we say it is, then it is equally necessary, if not more so, on a straight post, as it will give more security than will be apparent on a tapered post.

MR. FORD:—In standardizing we are trying to eliminate unnecessary types and not to initiate new types. The straight post was never made with a differential in size of positive and negative. The only kind of a straight post that was ever used was the same diameter for the positive and the negative. If we were to introduce straight posts having different diameters for positive and negative, we would be introducing something that is not in use.

(9) *Fuses and Fuse Clips*

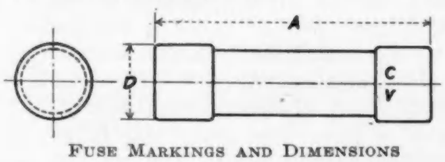
The present S.A.E. Standard printed on page B32, S.A.E. HANDBOOK, Vol. I (new edition), was originally adopted in January, 1914, and revised somewhat in 1918. With the development of electrical apparatus on automobiles the practice has become more established as regards the use of fuse sizes and capacities and as to the requirements of fuse tests. The Division corresponded with the manufacturers of fuses in order to obtain definite information as to best current practice. These data have been used in preparing the following recommendation which more definitely limits the number of fuse sizes and their capacities and includes what is considered ample testing requirements. The recommendation of the Electrical Equipment Division that the present standard be revised to read as follows was approved:

Fuses for use on circuits of 25 volts or less and 30 amp. or less shall be of the closed type and constructed so that inspection will show whether or not they have been melted.

Marking.—The voltage (V) and the current capacity (C) shall be plainly marked on one of the ferrules of each fuse. Fuses of the same dimensions as the National Electric Code shall be marked according to the requirements of that code.

Construction.—Fuses shall be constructed so that with the surrounding atmosphere at a temperature of 75 deg. fahr. (24 deg. cent.) they will carry indefinitely a current 10 per cent greater than that at which they are rated. With a current 50 per cent greater than the rating and at a room temperature of 75 deg. fahr. (24 deg. cent.) the fuses starting cold shall melt within 1 min.

The temperature of the exterior of the fuses shall rise not more than 125 deg. fahr. (70 deg. cent.) above that of the surrounding air when the fuse is carrying the current for which it is rated.



FUSE MARKINGS AND DIMENSIONS

Capacity, Amp.	Length, In. (A)	Ferrule Diameter, In. (B)
5	$1\frac{1}{4}$	$\frac{1}{4}$
10	$1\frac{1}{4}$	$\frac{1}{4}$
15	$1\frac{1}{4}$	$\frac{1}{4}$
20	$1\frac{1}{4}$	$\frac{1}{4}$
30	$1\frac{1}{2}$	$\frac{13}{32}$

Clips.—Fuse clips shall be made so that fuses cannot slip out accidentally and fastened to a base that cannot turn. Clips shall be designed and protected so that they cannot be drawn together enough to take a permanent set interfering with the insertion of the fuse or so that they can be sprung apart far enough to give them a permanent set sufficient to prevent holding the fuse tightly. Clips shall be nickel-plated.

Ferrules.—Fuse ferrules shall be nickel-plated.

Tests.—Fuses shall be tested in both the vertical and horizontal positions.

(10) *Spark-Plug Tests*

It has been evident for some time that some definite guide for the testing of spark-plugs will be of value to both spark-plug manufacturers and users. Last year the Division cooperated with the Motor Transport Corps in the establishment of a Government specification for the testing of spark-plugs and from this work developed the following recommendation for commercial use. The recommendation is not intended as an iron bound specification but rather as a definite guide towards the ready elimination of freak or inferior plugs. The recommendation was prepared by a Subdivision and tried out by making actual tests and in consultation with the spark-plug manufacturers. The recommendation of the Electrical Equipment Division that the specification printed below be adopted for S.A.E. Recommended Practice was approved.

A sufficient number of sample spark-plugs drawn at random from stock are to be furnished to equip at least two of the engines under consideration

The spark-plugs submitted for test must conform in all important dimensions to the engine builder's drawings

Preignition and leakage tests are to be made in the following manner. An engine of the type for which the plugs are intended shall be equipped with a set of the spark-plugs to be tested. The spark-plug gaps shall be carefully adjusted with a suitable thickness gage to the desired dimension and these gaps shall not be disturbed throughout the tests. The engine shall then be coupled to a suitable dynamometer and the circulating water maintained at a temperature of not less than 40 deg. fahr. or more than 60 deg. fahr. The engine shall then be started up and as rapidly as possible brought to the speed corresponding to the maximum torque, the throttle and the spark adjusted for this condition, and the circulating water temperature brought up to a temperature of not less than 190 deg. fahr. nor more than 210 deg. fahr. as rapidly as possible and this temperature maintained for the remainder of the run. Torque and speed readings shall then be taken at 30-sec. intervals for a period of 15 min. Appreciable loss of torque or speed, missing or backfiring which can be attributed to the spark-plugs, will be considered grounds for rejecting the spark-plugs under test, provided the engine is of proved design and has previously demonstrated its ability to run steadily under these conditions. During this run, tests for gas leakage shall be made by covering all joints of the spark-plugs with oil and inspecting for leaks.

Following this 15-min. run at the speed corresponding to maximum torque, the engine shall be brought up to the speed corresponding to maximum horsepower and be held at this speed for not less than 5 min. Observations similar to those mentioned above are to be made during this run.

Spark-plugs shall also be subjected to road tests to determine how well they will function under normal service conditions.

Spark-plugs which have successfully passed the above tests will be considered satisfactory for use insofar as the following points are concerned

(1) Breakage owing to sudden temperature changes

(2) Liability to cause preignition
(3) Leakage
(4) Power performance
(5) Permanence of gap

The following procedure for determining the relative susceptibility of the spark-plugs under test to fouling is intended to serve merely as a guide in making such tests, since general engine influences and more particularly lubrication and carburetion conditions, varying as they do in different makes of engine, prohibit the setting of one strictly standard method applicable to all engines.

The engine equipped with the spark-plugs under test shall be run on the dynamometer with the circulating water at not less than 40 deg. fahr. nor more than 60 deg. fahr. The inlet manifold shall be kept at as low a temperature as practicable, all heating means being disconnected so far as possible. The engine shall be run with no load and a wide-open throttle, the speed being held down to between 1000 and 1500 r.p.m. by causing the carbureter to feed an abnormally rich mixture. The engine shall be run in this manner for 3 min., following which the carbureter adjustment shall be restored to standard condition and the load applied to hold the engine at a speed of about 1200 r.p.m. It is assumed that the torque which is to be expected of the engine under test at this speed, has been previously determined. At the end of 2 min. running after applying the load as above explained, the percentage of standard torque which the engine is capable of developing will be considered as a figure of merit for the spark-plugs under test. For instance, if at the end of 2 min. operation under load following the "choked" run, the engine is capable of pulling its standard torque, the spark-plugs shall be considered 100 per cent satisfactory in this regard. If, however, the engine pulls but one-half its regular torque, the figure of merit will be 50. These tests should be repeated a sufficient number of times to insure a consistent average result.

(11) *Magneto Dimensions*

Since the adoption of the present standard printed on page B14, S.A.E. HANDBOOK, Vol. I (new edition), a small type motorcycle magneto has been developed on which there has been some variation of the threaded and taper shaft-end. It was requested by the Motorcycle Division that this variation be eliminated and a Subdivision which was accordingly assigned to prepare a report has recommended that for small motorcycle and isolated electric lighting plant magnetos the same size taper be used as given in the present recommended practice for larger type motorcycle magnetos printed in the S.A.E. HANDBOOK. The recommendation of the Electrical Equipment Division that the present S.A.E. Recommended Practice be extended to include the above was approved.

(12) *Starting-Motor Pinions*

The recommendation of the Electrical Equipment Division that the present S.A.E. Recommended Practice for Starting Motor Pinions, page B18, S.A.E. HANDBOOK, Vol. I (new edition), be revised to specify the clearance between the pinion and the flywheel on the pitch line was approved to read as follows:

> Flywheel starting motors shall be equipped with an 8-10 pitch, 11-tooth, 20-deg. pressure angle pinion. The clearance on the pitch line between the pinion and the flywheel shall be from 0.015 to 0.025 in.

THE DISCUSSION

GLENN MUFFLY:—What is meant by the pitch-line clearance? Frequently an engineer says that he reduces the pitch diameter of a gear, thereby giving a pitch-line clearance; that is technically impossible.

EARLE BUCKINGHAM:—The pitch-line of a gear does not exist until it is brought into contact with another gear. The pitch-line is the point where the line of action crosses the common center-line of two gears, so there could not be a pitch-line clearance.

MR. CRANE:—It will make the report clear if it is changed to read that the clearance on the pitch-line between the pinion and the flywheel shall be 0.015 to 0.025 in.

(13) *Brushes*

The Electrical Equipment Division was requested to ascertain whether a standard could not be established for starting motor and lighting generator brushes. After careful consideration of data pertaining to brush sizes and the possibility of the advantage of such a standard to the manufacturers of brushes by reducing the number of sizes of plates from which they are made, it was considered practical to establish a standard only for the steps by which brush dimensions should vary. The standard brush dimensions of the Electric Power Club as published August, 1920, were considered but as the sizes covered in general by this standard are larger than those used in automotive electrical equipment and as the increases between sizes are too large, the recommendation of the Electrical Equipment Division that the following standard be adopted for S.A.E. Recommended Practice was approved. This recommendation permits of obtaining brushes with small variation in contact surface on the commutator, and having but one set of tolerances for all sizes, these tolerances applying to the brushes before they are plated. It was not considered advisable to attempt standardization of chamfering or methods of fastening brush leads.

> All dimensions for brushes used in starting motors and lighting generators shall vary by even increments of 1/16 in. and the maximum tolerances from nominal size shall be plus 0.000 minus 0.010 in. for width and thickness and plus 0.000 minus 0.031 (1/32) in. for length.

(14) *Addition of Electrical Appliances to Gasoline Automobiles*

The present S.A.E. Standard which was adopted several years ago reads as follows:

> Before any electrical appliance is added to a gasoline car, after it is sent out from the car manufacturer's plant, a description of the said appliance should be submitted to the car manufacturer as to suitability for and the best method of application to the car.

It is the intention of the Society to make the S.A.E. HANDBOOK of the greatest value to the Society members and users of the standards. Such standards as the above are gradually being eliminated. If manufacturers and users attempted to abide by such a standard it would cause almost endless confusion and entail considerable expense without accomplishing any results. Such procedure as required by the standard is contrary to commonly accepted practice in placing many electrical appliances and accessories on motor cars. The recommendation of the Electrical Equipment Division that this standard be cancelled was approved.

ENGINE DIVISION REPORT

(15) *Mufflers*

When the suggestion for standardization of muffler mountings and connections was brought to the attention of the Engine Division, a Subdivision was formed

consisting of engine and muffler manufacturers. Investigation indicated that muffler capacity is too closely associated with engine design to warrant standardization in this direction. Opinions and practices as to methods of mounting seem to vary considerably, although muffler manufacturers seem to favor the use of bands as now recommended. The possibility of standardizing the exhaust and tail-pipe connection was considered but due to wide variation in types, practice and connections, it was thought better not to attempt such standardization until there is a sufficient demand for it.

In order to provide some definite guide for practice, the following, based on the Subdivision report, was recommended by the Engine Division and approved for adoption as S.A.E. Recommended Practice.

> Mufflers shall vary in diameter and length by even inches and shall be supported by bands extending around the circumference.

(16) *Flywheel Housings*

In connection with the present S.A.E. Standard Flywheel Housings, pages A1, A2 and A3, S.A.E. HANDBOOK, Vol. I (new edition) it was proposed that the maximum clearance dimensions for the crankshaft flange bolt be established to facilitate interchanging clutches and to provide for uniform design in assembled jobs. The original intention was to standardize the bolt-circle diameters and head clearances, but it was believed from study of present and possible future practice in connection with shaft bearing diameters, oil slingers and other controlling features, that there will be of necessity considerable variation.

It was therefore thought best to provide for a standard maximum clearance as a guide to clutch and engine manufacturers and the recommendation of the Engine Division to add the following to the present S.A.E. Recommended Practice was approved.

> The clearance space for crankshaft flange bolts shall be 6⅛ in. maximum diameter and at least ⅝ in. deep.

(17) *Fan-Belts and Pulleys*

The present standard which was adopted by the Society August, 1915, includes only four nominal belt widths, namely ¾, 1, 1¼ and 1½ in. The development of engines and cooling systems of larger capacity for truck and tractor work has required greater fan belt power. The request of the Truck Division to extend the number of belt widths has been acted upon by the Engine Division, whose recommendation that 1¾ and 2-in. belt widths and corresponding pulley widths be added to the present standard was approved. The complete revised standard as now recommended is as follows:

FAN-BELT AND PULLEY WIDTHS

Nominal Belt Width, In. ±1/32	Nominal Pulley Width, In. ±0.005
¾	0.875
1	1.125
1¼	1.375
1½	1.685
1¾	2.000
2	2.250

The Division is at present working on the subject of V-belts which are used to a considerable extent. It includes leather, rubber and canvas types and is apparently more involved by reason of the different angles of the V best suited to the operation of each and to differences in design. It is anticipated that a recommendation will be had for the next meeting of the Standards Committee.

(18) *Carbureter Intake*

With the advent of air-cleaners for use on tractors, it was felt by members of the Tractor Division that standardization should be provided especially for the air-cleaner outlet and the carbureter air inlet. The matter was assigned to the Engine Division which, after considerable study of the possibilities, decided that the only dimension on air-cleaners which should be standardized for the present at least is the outside diameter of the tubing leading from the air-cleaner outlet to the carbureter air intake. The Engine Division recommendation that the following be adopted as S.A.E. Recommended Practice was approved.

> The nominal diameter of the carbureter air intake shall be the inside diameter, which shall vary in even quarter inches (from ¾ to 4 in. diameters) so as to take standard tubing sizes as listed in the present S.A.E. Standard for Flexible Metal Tubing, page C54, S.A.E. HANDBOOK, Vol. I (new edition). This also applies to the outlet of carbureter air-cleaners, heaters and similar devices wherever tubing is used.

(19) *Carbureter Air Heaters*

The present S.A.E. Recommended Practice for Carbureter Air-Heaters was adopted by the Society in August, 1915, but with the more recent developments in apparatus to obtain efficient fueling of engine, this specification has become obsolete. The recommendation of the Engine Division that the present recommended practice for carbureter air heaters be cancelled was approved.

MISCELLANEOUS DIVISION REPORT

(20) *American Standard Taper Pipe Threads*

The American Standard Taper Pipe Threads, commonly known as the American Briggs Standard, which has been endorsed by the A.S.M.E. and a manufacturers' committee representing fittings, pipe and gage manufacturers, has been in use very generally in the United States.

The report of the National Screw Thread Commission, which was authorized by act of Congress in July, 1918, for the purpose of ascertaining and establishing standards for screw threads, includes the sizes and dimensions for taper pipe threads which correspond to those in the American taper pipe standard sizes.

In 1915 a movement was fostered by the American Gas Institute and the A.S.M.E. for the international standardization of taper pipe threads, but little was accomplished until in 1919 the Committee of the A.S.M.E. held a public hearing for the consideration of international pipe threads. Mr. Edwin H. Ehrman and Mr. Jerome J. Aull were appointed by the Council of the Society of Automotive Engineers to attend this hearing as a special committee and reported as follows:

> The Manual of American Standard Pipe Threads, dated October, 1919, was prepared by representative committees of valve and fitting, pipe and pipe thread gage manufacturers. It covers the entire subject of pipe sizes, threads, gages, tolerances, etc. in inch and metric measurements in very complete and accurate detail. While involving no change in present American pipe thread practice it clarifies and amplifies the subject in all its phases, particularly in the usage of gages and their tolerances.

Following the above hearing the Society was requested

to give official endorsement to the American standard and to authorize an American representative in Europe to use such endorsement in propagating the standard among European manufacturers and technical organizations prior to a contemplated international conference.

Although such a standard for taper pipe threads has not been considered by the Standards Committee of the Society it was deemed advisable to take official action on this matter in view of the proposed program for international standardization and the Society's connection with the project. The Council therefore assigned this subject to the Miscellaneous Division, which at its meeting on September 24, 1920, regularly voted to endorse the N.S.T.C. taper pipe thread specification providing that it does not differ in any essential features from that of the Committee of the A.S.M.E. pipe and fitting manufacturers. Although it was felt that this standard should be officially approved by the American Engineering Standards Committee it is thought desirable that the Society of Automotive Engineers take definite action if possible at this time by endorsing or adopting the report for standard. Only the diagram and table for the American Taper Pipe Thread Standard are given below as approved for adoption.

At present taper threads are used in only a few of the S.A.E Standards, namely, Flared Tube Unions, Ells and Tees, Fuel Vacuum Tanks, Pipe Flanges and Oil and Grease Cup Threads.

Diameter of Taper Thread The pitch diameters of the taper thread are determined by formulas based on the outside diameter of pipe and the pitch of thread. These are as follows:

$$A = D - (0.050D + 1.1)\ P$$
$$B = A + 0.0625F.$$

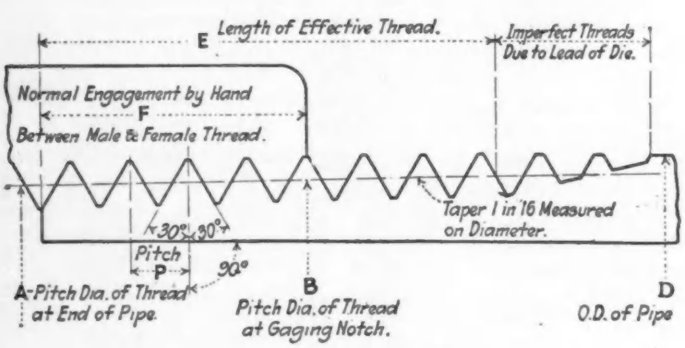
where A = Pitch diameter of thread at end of pipe
B = Pitch diameter of thread at gaging notch
D = Outside diameter of pipe
F = Normal engagement by hand between external and internal threads
P = Pitch of thread

NOTE—The above formulas are not expressed in the same terms as the formula originally established by Mr. Robert Briggs, because they are used to determine pitch diameters, whereas the Briggs formula determined the outside diameter of the thread. However, both forms give identical results.

The outside diameter of pipe is given in column D of the Table of dimensions. These diameters should be very closely adhered to by pipe manufacturers.

Profile The angle between the sides of the thread is 60 deg. when measured in the axial plane, and the thread is perpendicular to the axis of the pipe, for both taper and straight threads. The crest and root are truncated an amount equal to $0.033P$. The depth of the thread, therefore, is $0.80P$.

NOTE.—While Mr. Briggs originally advocated a slightly *rounded* crest and root, the thread as applied in the manufacture of gages and thread tools has always been slightly *flattened* at the crest and root. The crests on commercially manufactured male and female threads appear slightly rounded



AMERICAN STANDARD TAPER PIPE THREAD

DIMENSIONS OF AMERICAN STANDARD TAPER PIPE THREAD

Nominal Pipe Size		*A*		*B*		*D*		*E*		*F*		Depth of Thread		Number of Threads	
In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	Per In.	Per 254 Mm.
1/8	3	0.36351	9.233	0.37476	9.519	0.405	10.287	0.2638	6.700	0.180	4.572	0.02963	0.753	27	270
1/4	6	0.47739	12.126	0.48989	12.443	0.540	13.716	0.4018	10.206	0.200	5.080	0.04444	1.129	18	180
3/8	10	0.61201	15.545	0.62701	15.926	0.675	17.145	0.4078	10.358	0.240	6.096	0.04444	1.129	18	180
1/2	13	0.75843	19.264	0.77843	19.772	0.840	21.336	0.5337	13.556	0.320	8.128	0.05714	1.451	14	140
3/4	19	0.96768	24.579	0.98886	25.117	1.050	26.670	0.5457	13.861	0.339	8.611	0.05714	1.451	14	140
1	25	1.21363	30.826	1.23863	31.461	1.315	33.401	0.6828	17.343	0.400	10.160	0.06956	1.767	11½	115
1¼	32	1.55713	39.551	1.58338	40.218	1.660	42.164	0.7068	17.953	0.420	10.668	0.06956	1.767	11½	115
1½	38	1.79609	45.621	1.82234	46.287	1.900	48.260	0.7235	18.377	0.420	10.668	0.06956	1.767	11½	115
2	50	2.26902	57.633	2.29627	58.325	2.375	60.325	0.7565	19.215	0.436	11.074	0.06956	1.767	11½	115
2½	64	2.71953	69.076	2.76216	70.159	2.875	73.025	1.1375	28.892	0.682	17.323	0.10000	2.540	8	80
3	76	3.34063	84.852	3.38850	86.068	3.500	88.900	1.2000	30.480	0.766	19.456	0.10000	2.540	8	80
3½	90	3.83750	97.473	3.88881	98.776	4.000	101.600	1.2500	31.750	0.821	20.853	0.10000	2.540	8	80
4	100	4.33438	110.093	4.38713	111.433	4.500	114.300	1.3000	33.020	0.844	21.438	0.10000	2.540	8	80
4½	113	4.83125	122.714	4.88594	124.103	5.000	127.000	1.3500	34.290	0.875	22.225	0.10000	2.540	8	80
5	125	5.39073	136.925	5.44929	138.412	5.563	141.300	1.4063	35.720	0.937	23.800	0.10000	2.540	8	80
6	150	6.44609	163.731	6.50597	165.252	6.625	168.275	1.5125	38.417	0.958	24.333	0.10000	2.540	8	80
7	175	7.43984	188.972	7.50234	190.560	7.625	193.675	1.6125	40.957	1.000	25.400	0.10000	2.540	8	80
8	200	8.43359	214.214	8.50003	215.901	8.625	219.075	1.7125	43.497	1.063	27.000	0.10000	2.540	8	80
9	225	9.42734	239.455	9.49797	241.249	9.625	244.475	1.8125	46.037	1.130	28.702	0.10000	2.540	8	80
10	250	10.54531	267.851	10.62094	269.772	10.750	273.050	1.9250	48.895	1.210	30.734	0.10000	2.540	8	80
11	275	11.53906	293.093	11.61938	295.133	11.750	298.450	2.0250	51.435	1.285	32.639	0.10000	2.540	8	80
12	300	12.53281	318.334	12.61781	320.493	12.750	323.851	2.1250	53.975	1.360	34.544	0.10000	2.540	8	80
14 O.D.	350	13.77500	349.886	13.87262	352.365	14.000	355.601	2.2500	57.150	1.562	39.675	0.10000	2.540	8	80
15 O.D.	375	14.76875	375.127	14.87419	377.805	15.000	381.001	2.3500	59.690	1.687	42.850	0.10000	2.540	8	80
16 O.D.	400	15.76250	400.368	15.87575	403.245	16.000	406.401	2.4500	62.230	1.812	46.025	0.10000	2.540	8	80
17 O.D.	425	16.75625	425.609	16.87500	428.626	17.000	431.801	2.5500	64.770	1.900	48.260	0.10000	2.540	8	80
18 O.D.	450	17.75000	450.851	17.87500	454.026	18.000	457.201	2.6500	67.310	2.000	50.800	0.10000	2.540	8	80
20 O.D.	500	19.73750	501.333	19.87031	504.707	20.000	508.001	2.8500	72.390	2.125	53.975	0.10000	2.540	8	80
22 O.D.	550	21.72500	551.816	21.86562	555.388	22.000	558.801	3.0500	77.470	2.250	57.150	0.10000	2.540	8	80
24 O.D.	600	23.71250	602.299	23.86094	606.069	24.000	609.601	3.2500	82.550	2.375	60.325	0.10000	2.540	8	80
26 O.D.	650	25.70000	652.781	25.85625	656.750	26.000	660.401	3.4500	87.630	2.500	63.500	0.10000	2.540	8	80
28 O.D.	700	27.68750	703.264	27.85156	707.431	28.000	711.201	3.6500	92.710	2.625	66.675	0.10000	2.540	8	80
30 O.D.	750	29.67500	753.746	29.84687	758.112	30.000	762.001	3.8500	97.790	2.750	69.850	0.10000	2.540	8	80

The dimensions of American Pipe Threads are expressed in "inches" to 0.00001 in., and in "millimeters" to 0.001 mm. While this is a greater degree of accuracy than is ordinarily used, the dimensions are so expressed to eliminate errors which might result from less accurate dimensions.

The relation between the inch and the meter used in calculating the dimensions in these tables is that established by law in the United States and on record in the Bureau of Standards, Department of Commerce and Labor, Washington. This is 1 meter = 39.37 in. exactly. The metric equivalent of the inch resulting from this determination is 25.40005 mm.

when examined with a microscope, but for all practical purposes, when examined by eye, they are sharp. The roots of commercially manufactured threads are practically sharp when cut with new tools and slightly rounded when cut with worn tools.

Pitch The pitch of the thread is expressed in terms of the number of threads in 1 in. or the number of threads in 254 mm. (254 mm. equals 10 in.).

Length of Thread The length of the taper external or male thread is determined by a formula based on the outside diameter of pipe and the pitch of the thread. This is as follows:

$$E = (0.80D + 6.8)\,P$$

where E = Length of effective thread
G = Outside diameter of pipe
P = Pitch of thread

NOTE.—The formula is not expressed in the same terms as the one originally established by Mr. Briggs, since it determines directly the length of *effective* thread which includes two threads slightly imperfect on the crest, whereas the Briggs formula determined the length of *perfect* thread, not including the two threads imperfect on the crest. However, both forms of the formula give identical results.

Engagement between Taper Male and Female Threads The normal length of engagement between taper male and female threads when screwed together by hand is shown in Column F of the Table. This length is controlled by the construction and use of the gages.

THE DISCUSSION

CHAIRMAN BACHMAN:—The American Standard for taper pipe threads which is in general practice was approved by the American Engineering Standards Committee as the American Standard in December, 1919. It is now within the province of the Society to accept it and to recognize it as an S. A. E. Standard for our work. Of course, the range of pipe and pipe-thread sizes used in some of the fields of automotive work is limited; in others it is more extensive.

MR. AULL:—I question whether the name "American Standard" is correct. I believe I am right when I say that the National Screw Thread Commission calls it a National Standard.

CHAIRMAN BACHMAN:—There has been some division of opinion on that point. My understanding of the procedure of the American Engineering Standards Committee, of which I am a member, is that standards that have been approved by that body take the name "American Standards."

MR. AULL:—Personally, I am in favor of "American Standard" because "National Standard" conveys nothing to me, while "American Standard" does.

MR. BUCKINGHAM:—American Standard is the name by which it is known.

(21) *Oil and Grease Cup-Threads*

The present recommended practice for oil and grease-cup threads which was adopted by the Society in August, 1920, includes straight thread sizes for ¼-36 and 5/16-32 threads only. The common standard fine thread pitch for ¼ in. diameter is 32, but the corresponding thread adopted by the Society, principally for aeronautic purposes, was 36 threads. The previous recommendation for oil-cups of this size was adopted in order to if possible conform to the existing S.A.E. fine thread. This size has been quite generally criticized as being contrary to practically universal practice, such criticisms coming principally from the largest manufacturers of this article. The Miscellaneous Division has therefore reconsidered its previous action and recommended the addition of a No. 10-32 size and the revision of the ¼-36 to ¼-32 in the belief that such a standard will conform to general practice and at the same time be limited to only those sizes which will remain in permanent use. No change is contemplated in the present standard for the pipe thread sizes of grease and oil-cups and the above recommendation has been approved.

MOTORCYCLE DIVISION REPORT

(22) *Spokes and Nipples*

The present S.A.E. Recommended Practice for Motorcycle Spokes and Nipples, page F4, S.A.E. HANDBOOK, Vol. I (new edition), specifies a steel having a chemical composition slightly different from that of S.A.E. Steel No. 1045. The two compositions are given for comparison.

	Present Specified Composition	S.A.E. Steel No. 1045
Carbon	0.40 to 0.55 per cent	0.40 to 0.50 per cent
Manganese, min...	0.50 per cent	0.50 to 0.80 per cent
Phosphorus, max..	0.05 per cent	0.045 per cent
Sulphur, max.....	0.05 per cent	0.05 per cent

In order to have the specification conform to the standard steel it was referred to the motorcycle manufacturers, who advised that their specifications either call for S.A.E. Steel No. 1045 or can be changed to do so, and that spokes made to this analysis will be entirely satisfactory. The Division's recommendation that the present recommended practice be revised to specify S.A.E. Steel No. 1045 has been approved.

(23) *Motorcycle Wheels and Rims*

The present S.A.E. Recommended Practice for Motorcycle Wheels and Rims, page G9, S.A.E. HANDBOOK, Vol. I (new edition), specifies a steel composition for rims which is very nearly the same as Steel No. 1010 as indicated below:

	Present Specified Composition	S.A.E. Steel No. 1010
Carbon	0.10 to 0.15 per cent	0.05 to 0.15 per cent
Manganese	0.40 to 0.60 per cent	0.30 to 0.60 per cent
Phosphorus, max..	0.05 per cent	0.045 per cent
Sulphur, max.....	0.05 per cent	0.05 per cent

S.A.E. steel No. 1010 will be as satisfactory as those made of the non-standard steel at present specified in the HANDBOOK and as it is desired to eliminate the non-standard steel specification, the Division's recommendation that the present S.A.E. Recommended Practice for Motorcycle Wheels and Rims be revised to specify S.A.E. Steel No. 1010 was approved.

(24) *Motorcycle Controls*

The Motorcycle Division has recommended that the present S.A.E. Recommended Practices for spark and throttle controls, clutch and brake pedals and gearshift, which were formulated as military motorcycle standards, be withdrawn, as they are not applicable to commercial practice owing to the different constructions used in present-day machines necessitating different locations and movements of controls. The cancellation of these recommended practices was approved.

The recommended practices are printed on page J8, S.A.E. HANDBOOK, Vol. I (new edition).

NON-FERROUS METALS DIVISION REPORT

The existing standards of the Society were adopted from seven to nine years ago with very slight revisions since then. Development in the production and use of non-ferrous metals and alloys has reached a point where the existing standard specifications are very inadequate. The Non-Ferrous Metals Division has therefore prepared

the following report for non-ferrous alloys which have been grouped into five general classes. These proposed specifications are considered ample for general automotive purposes and have been arranged so far as possible so as to give information relative to the general use of each alloy, its chemical composition and in most cases, physical properties. The numbering system has been arranged with sufficient flexibility to insert added specifications as conditions may require. The compositions have been carefully developed with regard to what is considered best metallurgical practice as well as specifications used by the Government and recommended by such other organizations as the American Society for Testing Materials. It is expected that the recommended specifications will become as important an S.A.E. Standard as the present standard steels. The recommendation of the Non-Ferrous Metals Division that these specifications be adopted as S.A.E. Standard was approved. They will supersede the non-ferrous specifications now in the S.A.E. HANDBOOK with the exception of the present aluminum specifications Nos. 30, 31 and 32 which will be retained.

(25) *Non-Ferrous Metal Specifications*

WHITE BEARING METALS

Specification No. 11, Babbitt.

Composition in percentage:

Tin	86.00 to 89.00
Copper	5.00 to 6.50
Antimony	6.00 to 7.50
Lead, max.	0.35
Iron, max.	0.08
Arsenic, max.	0.10
Bismuth, max.	0.08
Zinc	None
Aluminum	None

General Information

This is a rather hard babbitt which may be used for lining connecting-rod and shaft bearings which are subjected to heavy pressures; its "wiping" tendency is very slight. It is also suitable for die castings.

Specification No. 12, Babbitt.

Composition in percentage:

Antimony	9.50 to 11.50
Copper	2.25 to 3.75
Lead	24.00 to 26.00
Iron, max.	0.08
Bismuth, max.	0.08
Zinc	None
Aluminum	None
Tin	Remainder

General Information

This is a relatively cheap babbitt and is intended for bearings subjected to moderate pressures. It is also suitable for die castings.

Specification No. 10, Babbitt.

Composition in percentage:

Tin	90.00 to 92.00
Copper	4.00 to 5.00
Antimony	4.00 to 5.00
Lead, max.	0.35
Iron, max.	0.08
Arsenic, max.	0.10
Bismuth, max.	0.08
Zinc	None
Aluminum	None

This analysis applies to the metal in the ingot form. When finished bearings are purchased a maximum of 0.6 per cent lead is permissible in scraped samples provided a lead-tin solder has been used in bonding the bronze and the babbitt.

General Information

This babbitt is very fluid and may be used for bronze-backed bearings, particularly for thin linings such as are used in aircraft engines. It is also suitable for die castings.

Specification No. 13, Babbitt.

Composition in percentage:

Tin	4.50 to 5.50
Antimony	9.25 to 10.75
Copper, max.	0.50
Lead	84.00 to 86.00
Arsenic, max.	0.20
Zinc	None
Aluminum	None

General Information

This is a cheap babbitt and serves successfully where the bearings are large and the service light. It should not be used as a substitute for a babbitt with a high tin content. It is also suitable for die castings.

ALUMINUM ALLOYS

Specification No. 30.

Composition in percentage:

Aluminum, min.	90.00
Copper	7.00 to 8.50
Zinc, max.	0.20
Silicon, Iron, Zinc, Manganese and Tin, max.	1.70
Other Impurities	None

General Information

The tensile strength of test-specimens about ½ in. diameter of this alloy cast in sand and tested without machining off the skin should be about 18,000 to 20,000 lb. per sq. in. and the elongation 1 to 2 per cent in 2 in.

This is a light alloy having a specific gravity of about 2.83 and is used more extensively in the automotive industry than all other light casting alloys combined. A shrinkage of 0.156 (5/32) in. per ft. should be allowed in pattern designs. This alloy is used for crankcases, oil-pans, steering-wheel spiders, differential carriers, transmission cases, camshaft housings, hub-caps and similar parts.

Specification No. 31.

Composition in percentage:

Aluminum, min.	81.00
Copper	2.25 to 3.25
Zinc	12.50 to 14.50
Silicon, Iron, Manganese and Tin, max.	1.70
Other Impurities	None

General Information

The tensile strength of test-specimens about ½-in. diameter of this alloy cast in sand and tested without machining off the skin should be about 25,000 to 30,000 lb. per sq. in. with an elongation of more than 1 per cent in 2 in.

The specific gravity is about 3.0 and a shrinkage of 0.156 (5/32) in. per ft. should be allowed in pattern designs.

This alloy is used extensively in England for such parts as crankcases, oil-pans, steering-wheel spiders and transmission cases.

Specification No. 32.

Composition in percentage:

Aluminum, min.	85.50
Copper	11.00 to 13.50
Zinc, max.	0.20
Silicon, Iron, Zinc, Manganese and Tin, max.	1.70
Other Impurities	None

General Information

The tensile strength of test-specimens about ½-in. diameter of this alloy cast in sand and tested without machining off the skin

should be about 19,000 to 23,000 lb. per sq. in. and the elongation will be practically nothing.

The specific gravity of this alloy is about 2.95 and a shrinkage of 0.156 (5/32) in. per ft. should be allowed in pattern designs. This alloy is used for manifolds, pumps, carbureters, cylinders and other parts which should be free from leaks and where the brittleness of the alloy is not objectionable.

Specification No. 33.

Composition in percentage:

Aluminum	88.00 to 92.00
Copper	6.00 to 8.00
Zinc, max.	2.50
Iron, max.	1.50
Silicon, Manganese and Tin, max.	0.75
Other Impurities	None

General Information

The tensile strength of test-specimens about ½-in. diameter of this alloy cast in sand and tested without machining off the skin should be about 19,000 to 21,000 lb. per sq. in. with an elongation of 1 to 2 per cent in 2 in.

This is a light alloy having a specific gravity of 2.83 to 2.86 and is used extensively in the automotive industry. A shrinkage of 0.156 (5/32) in. per ft. should be allowed in pattern designs.

This alloy is similar to Specification No. 30 and is used for crankcases, oil-pans, steering-wheel spiders, differential carriers, transmission cases, camshaft housings, hub-caps and similar parts.

Cast Brass Alloys

Specification No. 40 (Old No. 27), Red Brass.

Composition in percentage:

Copper	83.00 to 86.00
Tin	4.50 to 5.50
Lead	4.50 to 5.50
Zinc	4.50 to 5.50
Iron, max.	0.35
Antimony, max.	0.25
Aluminum	None

General Information

Good castings made of this alloy should give the following minima in physical characteristics:

Ultimate strength, lb. per sq. in.	27,000
Yield point, lb. per sq. in.	12,000
Elongation in 2 in. or proportionate gage length, per cent	16

This is a free-cutting brass with good casting and finishing properties.

Specification No. 43 (Old No. 29), Manganese Bronze.

Composition in percentage:

Copper	53.00 to 62.00
Zinc	38.00 to 47.00
Lead, max.	0.15

This metal may be hardened by the addition of small amounts of tin, iron, manganese, aluminum or combination of these metals. The most importance should be placed on the following minima in physical requirements:

Ultimate strength, lb. per. sq. in.	60.000
Yield point, lb. per sq. in.	30,000
Elongation in 2 in. or proportionate gage length, per cent	15

General Information

This alloy is intended for use in castings where strength and toughness are required. It is equivalent to the copper-zinc alloys commercially known as Cast Manganese Bronze or its equivalents, such as Cast Tobin Bronze and Cast Naval Bronze.

Specification No. 41 (Old No. 28), Yellow Brass.

Composition in percentage:

Copper	62.00 to 65.00
Lead	2.00 to 4.00
Zinc	31.00 to 36.00
Tin, max.	1.00
Iron, max.	0.50
Aluminum	None
Other Impurities	0.25

General Information

Good castings made of this alloy should give the following minima in physical characteristics:

Ultimate strength, lb. per sq. in.	25,000
Yield point, lb. per sq. in.	12,000
Elongation in 2 in. or proportionate gage length, per cent	20

This alloy is intended for use in commercial castings where cheapness and good machining properties are the main considerations.

Specification No. 42, White Nickel Brass.

Composition in percentage:

Copper	55.00 to 64.00
Nickel, min.	18.00
Iron, max.	0.35
Aluminum	None
Other Impurities	0.25
Zinc	Remainder

General Information

Good castings made of this alloy should give the following minima in physical characteristics:

Ultimate strength, lb. per sq. in.	30,000
Elongation in 2 in. or proportionate gage length, per cent	20

This brass is intended for use for trimmings or other parts requiring a metallic-white finish. The higher the nickel content, the more permanent will be the color.

Bronze Alloys

Bearings or gears made of bronze alloys should be used only against hardened steel.

Specification No. 62 (Old No. 43), Hard Cast Bronze

Composition in percentage:

Copper	86.00 to 89.00
Tin	9.00 to 11.00
Lead, max.	0.20
Iron, max.	0.06
Zinc	1.00 to 3.00

General Information

Good castings made of this bronze should give the following minima in physical characteristics:

Ultimate strength, lb. per sq. in.	30,000
Yield point, lb. per sq. in.	15,000
Elongation in 2 in. or proportionate gage length, per cent	14

This alloy is suitable wherever a strong general utility bronze is required. It may be used for severe working conditions where heavy pressures obtain, as in gears and bearings.

Specification No. 63, Leaded Gun Metal.

Composition in percentage:

Copper	86.00 to 89.00
Tin	9.00 to 11.00
Phosphorus, max.	0.25
Zinc and Other Impurities max.	0.50
Lead	1.00 to 2.50

General Information

Good castings made of this alloy should give the following minima in physical characteristics:

Ultimate strength, lb. per sq. in.	30,000
Yield point, lb. per. sq. in.	12,000
Elongation in 2 in. or proportionate gage length, per cent	10

Combining strength with fair machining qualities, this general utility bronze is especially good for bushings subjected to heavy loads and severe working conditions.

Specification No. 65, Phosphor Gear Bronze.

Composition in percentage:

Copper	88.00 to 90.00
Tin	10.00 to 12.00
Phosphorus	0.10 to 0.30
Lead, Zinc and Other Impurities, max.	0.50

General Information

Good castings made of this alloy should give the following minima in physical characteristics:

Ultimate strength, lb. per sq. in.	35,000
Yield point, lb. per sq. in.	20,000
Elongation in 2 in. or proportionate gage length, per cent	10

This is a very hard bronze and may be used for gears and worm wheels where the requirements are severe.

Specification No. 64 (Old No. 26), Phosphor Bronze.

Composition in percentage:

Copper	78.50 to 81.50
Tin	9.00 to 11.00
Lead	9.00 to 11.00
Phosphorus	0.05 to 0.25
Zinc, max.	0.75
Other Impurities, max.	0.25

General Information

Good castings made of this alloy should give the following minima in physical characteristics:

Ultimate strength, lb. per sq. in.	25,000
Yield point, lb. per sq. in.	12,000
Elongation in 2 in. or proportionate gage length, per cent	8

This metal is an excellent composition for use where anti-friction qualities are desired, standing up exceedingly well under heavy loads and severe usage.

Specification No. 66, Bronze Backing for Lined Bearings.

Composition in percentage:

Copper	83.00 to 86.00
Tin	4.50 to 6.00
Lead	8.00 to 10.00
Zinc, max.	2.00
Impurities, max.	0.25

General Information

Good castings made of this alloy should give the following minima in physical characteristics:

Ultimate strength, lb. per sq. in.	25,000
Yield point, lb. per sq. in.	12,000
Elongation in 2 in. or proportionate gage length, per cent	8

This composition is recommended as an inexpensive but suitable alloy for bronze-backed bearings.

Specification No. 67, Semi-Plastic Bronze.

Composition in percentage:

Copper	75.50 to 78.50
Tin	7.25 to 8.75
Lead	13.50 to 16.50
Zinc, max.	0.50
Phosphorus, max.	0.25
Iron, max.	0.25
Antimony, max.	0.50
Aluminum	None
Impurities, max.	0.75

General Information

Good castings made of this alloy should give the following minima in physical characteristics:

Ultimate strength, lb. per sq. in.	20,000
Elongation in 2 in. or proportionate gage length, per cent	10

This metal is intended for use where a soft bronze with good anti-friction qualities is desired.

Specification No. 68, Cast Aluminum Bronze.

Composition in percentage:

Copper	85.00 to 87.00
Aluminum	7.00 to 9.00
Iron	2.50 to 4.50
Tin (none desired), max.	0.50
Other Impurities, max.	0.25

General Information

Good castings made of this alloy should give the following minima in mechanical properties:

Ultimate strength, lb. per sq. in.	65,000
Yield point, lb. per sq. in.	20,000
Elongation in 2 in. or proportionate gage length, per cent	20

This is a non-corrodible alloy of great strength with a hardness equal to that of manganese bronze and good bearing qualities. It is suitable for use in worm wheels, gears and similar parts.

Specification No. 69, Wrought Aluminum Bronze.

Composition in percentage:

Copper	85.00 to 87.00
Aluminum	7.00 to 9.00
Iron	2.50 to 4.50
Tin (none desired), max.	0.50
Other Impurities	0.25

General Information

Wrought shapes, rods and bars of this alloy, the composition of which is identical with Specification No. 68, combine unusual strength with good bearing and anti-corrosive qualities.

Wrought bars made of this alloy, when annealed or hot-rolled, should give the following minima in physical characteristics:

Diameter or Thickness, In.		Ultimate Strength, Lb. per Sq. In.	Yield Point, Lb. Per Sq. In.	Elongation in 2 In. or Proportionate Gage Length, Per Cent
Over	To and Including			
0	1/2	80,000	40,000	30
1/2	1	75,000	37,500	28
1		72,000	35,000	25

COMMERCIAL BRASS SHEET

Specification No. 70.

This alloy may be used for general purposes for which sheet brass is suitable.

Composition in percentage:

Copper	64.50 to 67.50
Lead, max.	0.35
Iron, max.	0.06
Other Impurities, max.	0.10
Zinc	Remainder

Physical Requirements

Temper and Anneal.—The temper of sheet brass shall be designated as follows:

	Reduction, B. & S. Gage Nos.
Quarter Hard	1
Half Hard	2
Hard	4
Extra Hard	6
Spring	8

The annealed sheet shall be designated as follows:

Light Anneal.
Drawing Anneal.
Soft Drawing Anneal.

Mechanical Requirements

The average of tension tests of two samples of sheet thinner than 0.080 in. shall conform to the following minimum requirements:

Temper	Minimum Ult. Strength, Lb. Per Sq. In.	Minimum Elongation in 2 In., Per Cent
Quarter Hard	45,000	27.5
Half Hard	52,500	15.0
Hard	67,500	5.0
Extra Hard	80,000	2.0
Spring	87,500	1.0
Light Anneal	45,000	32.0
Drawing Annea	42,000	38.0
Soft Drawing Annea	40,000	42.0

In very thin strips, on account of the difficulties in testing, the elongation may be considerably less than the figures given above.

THICKNESS TOLERANCES

B. & S. Gage No.		Decimal		Up to 5 in. Wide, Incl.	Over 5 in. to 8 in. Wide, Incl.	Over 8 in. to 11 in. Wide, Incl.	Over 11 in. to 14 in. Wide, Incl.
From	To	From	To				
0000	0	0.4600	0.3249	0.0044	0.0048	0.0051	0.0055
1	4	0.2893	0.2043	0.0039	0.0043	0.0046	0.0050
5	8	0.1819	0.1285	0.0034	0.0038	0.0041	0.0045
9	14	0.1144	0.0641	0.0029	0.0033	0.0036	0.0040
15	18	0.0571	0.0403	0.0025	0.0029	0.0033	0.0037
19	24	0.0359	0.0201	0.0020	0.0024	0.0028	0.0032
25	28	0.0179	0.0126	0.0016	0.0020	0.0024	0.0028
29	32	0.0113	0.0079	0.0013	0.0017	0.0020	0.0024
33	35	0.0071	0.0056	0.0010	0.0014	0.0017	0.0022
36	38	0.0050	0.0040	0.0008	0.0012	0.0015	0.0019

All dimensions in inches. All tolerances plus or minus.

The average Brinell hardness of 10 samples of sheet 0.080 in. or over in thickness shall be within the following limits:

Quarter Hard	75–95
Half Hard	95–115
Hard	130–150
Extra Hard	150–170
Spring	160–180
Light Anneal	65–75
Drawing Anneal	55–65
Soft Drawing Anneal	47–55

These should be considered as general specifications. Since high brass is used for many purposes where the requirements of the operations used are too particular to be specified by any of the ordinary physical tests, it is frequently advisable to submit samples or drawings to the manufacturer and secure an adjustment of anneal or temper to suit the actual operations to which the material is to be submitted.

Copper Sheet

Specification No. 71.

Composition in percentage:

Copper, min.	99.50

Mechanical Requirements

ULTIMATE STRENGTH AND ELONGATION

Sheet	Ultimate Strength, Min., Lb. Per Sq. In.	Elongation in 2 In., Min., Per Cent
Soft	30,000	25
Hard-Rolled	35,000	18

Bend Test.—Test-pieces cut either way of the grain must stand cold-bending flat on themselves without cracking.

THICKNESS TOLERANCES

B. & S. Gage No.		Decimal		Up to 5 in. Wide, Incl.	Over 5 in. to 8 in. Wide, Incl.	Over 8 in. to 11 in. Wide, Incl.	Over 11 in. to 14 in. Wide, Incl.
From	To	From	To				
0000	0	0.4600	0.3249	0.0044	0.0048	0.0051	0.0055
1	4	0.2893	0.2043	0.0039	0.0043	0.0046	0.0050
5	8	0.1819	0.1285	0.0034	0.0038	0.0041	0.0045
9	14	0.1144	0.0641	0.0029	0.0033	0.0036	0.0040
15	18	0.0571	0.0403	0.0025	0.0029	0.0033	0.0037
19	24	0.0359	0.0201	0.0020	0.0024	0.0028	0.0032
25	28	0.0179	0.0126	0.0016	0.0020	0.0024	0.0028
29	32	0.0113	0.0079	0.0013	0.0017	0.0020	0.0024
33	36	0.0071	0.0050	0.0010	0.0014	0.0017	0.0022
37	40	0.0045	0.0031	0.0008	0.0012	0.0015	0.0019

All dimensions in inches. All tolerances plus or minus.

Free-Cutting Brass Rod

Specification No. 72 (Old No. 40).

This metal is intended for all purposes for which free-cutting, commercial brass rod is used.

Composition in percentage:

Copper	60.00 to 63.00
Lead	2.25 to 3.25
Iron, max.	0.15
Other Impurities, max.	0.25
Zinc	Remainder

When several bars or rods are analyzed they should meet this specification. If only one rod or bar is sampled, the following limits will be acceptable:

Copper, per cent	59.40 to 63.60
Lead, per cent	1.80 to 3.90

Mechanical Requirements

Bend Test.—Rods or bars shall bend cold without fracture through an angle of 120 deg. around a pin the radius of which is equal to the diameter or thickness of the rod or bar.

Dimensions and Tolerances.—The diameter of round sections shall not vary from that specified by more than the tolerances given in the following table:

DIMENSIONS AND TOLERANCES

Diameter, In.		Tolerances, In. Plus or Minus
Over	To and Including	
	½	0.0015
½	1	0.0020
1	2½	0.0025
2½		0.0030

In the case of other than round sections the distance between parallel faces shall be permitted to vary, in their respective sizes, double the amount of the above tolerances.

Naval Brass Rod

Specification No. 73.

Composition in percentage:

Copper	59.00 to 62.00
Tin	0.50 to 1.50
Iron, max.	0.10
Lead, max.	0.30
Other Impurities, max.	0.10
Zinc	Remainder

Mechanical Requirements

TENSILE TEST DATA

Diameter or Thickness, In.		Minimum Tensile Strength, Lb. Per Sq. In.	Minimum Yield Point, Lb. Per Sq. In.	Minimum Elongation in 2 In., Per Cent
Over	To and Including			
	1	62,000	31,000	25.0
1	2½	60,000	30,000	30.0
2½	3½	56,000	25,000	35.0
3½		54,000	22,000	40.0

Strain Test.—A full-size test-specimen must stand immersion for 15 min. without cracking in an aqueous solution containing 100 grams of mercurous nitrate and 13 cc. of nitric acid (specific gravity 1.42) per liter.

Bend Test.—The rods shall stand cold-bending without fracture through an angle of 120 deg. around a pin, the radius of which is equal to the diameter or thickness of the rod or bar.

Dimensions and Tolerances.—The diameter of round sections shall not vary from that specified by more than the tolerances specified in the following table.

DIMENSIONS AND TOLERANCES

Diameter, In.		Tolerances, In. Plus or Minus
Over	To and Including	
0	½	0.0015
½	1	0.0020
1	2½	0.0025
2½		0.0030

In case of other than round sections the distance between parallel faces shall be permitted to vary, in their respective sizes, double the amount of the above tolerances.

General Information

This material is intended for use wherever brass rod that is stronger, tougher, and less corrodible than commercial brass rod is required.

Seamless Brass Tubing

Specification No. 74.

This tubing is intended for all purposes for which annealed seamless brass tubing is used.

Composition in percentage:

Copper, min.	60.00
Lead, max.	1.00
Iron, max.	0.10
Zinc	Remainder

Mechanical Requirements

Tensile Test

Ultimate strength, min., lb. per sq. in., 40,000.

Elongation in 2 in. or proportionate gage length, min., per cent, 25.

Expanding Test.—A pin having a taper of 1 to 8 shall be driven into one end of a tube until the diameter is increased 15 per cent. The tube shall withstand this test without showing cracks, splits or other defects.

Appearance.—These tubes shall be clean, smooth and free from injurious defects, both inside and outside.

OUTSIDE AND INSIDE DIAMETER TOLERANCES

Diameter (D), In.[1]		Tolerances, In. Plus or Minus
Over	To and Including	
0	½	0.002
½	¾	0.0025
¾	1 in.	0.003
1 in.	1¼	0.0035
1¼	1½	0.004
1½	1¾	0.0045
1¾	2	0.005
2		0.0025D

[1]Applies to both inside and outside diameters.

No combination of variations on the same tube shall make the thickness of the wall vary from the nominal by more than the amounts given in the following table.

WALL THICKNESS TOLERANCES

Wall Thickness, In.		Tolerances, In. Plus or Minus
Over	To and Including	
0	1/64	0.001
1/64	1/32	0.002
1/32	1/16	0.003
1/16	1/8	0.005
1/8	1/4	0.008
1/4	5/16	0.0125
5/16	3/8	0.015

Special Limits.—On all stock where the above commercial variations are not permissible, the limits shall be specified in the order.

Copper Tubing

Specification No. 75.

Composition in percentage:

Copper, min.	99.50

Mechanical Requirements, Hard-Drawn Tubes

Expanding Test.—A pin having a taper of 1 to 8 shall be driven into one end of a tube until the diameter is increased 15 per cent. The tube must withstand the test without showing cracks, splits or other defects.

Bend Test.—One test-specimen cut longitudinally and one cut transversely from the tube shall be tested. Test-specimens must withstand cold-bending through an angle of 180 deg. on a radius equal to the thickness of the wall of the tube without cracking.

Mechanical Requirements, Annealed Tubes

Expanding Test.—A pin having a taper of 1 to 8 shall be driven into one end of a tube until the diameter is increased 15 per cent. The tube must withstand the test without showing cracks, splits or other defects.

Bend Test.—One test-specimen cut longitudinally and one cut transversely from the tube shall be tested. Test-specimens must withstand bending through an angle of 180 deg., that is flat on itself, without cracking. The metal must not crack when hammered to a fine edge.

Appearance.—These tubes shall be clean, smooth and free from injurious defects, both inside and outside.

OUTSIDE AND INSIDE DIAMETER TOLERANCES

Diameter (D), In.		Tolerances, In. Plus or Minus
Over	To and Including	
0	½	0.002
½	¾	0.0025
¾	1	0.003
1	1¼	0.0035
1¼	1½	0.004
1½	1¾	0.0045
1¾	2	0.005
2		0.0025D

No combination of variations on the same tube shall make the thickness of the wall vary from the nominal by more than the amounts given in the following table.

WALL THICKNESS TOLERANCES

Wall Thickness, In.		Tolerances, In., Plus or Minus
Over	To and Including	
0	1/64	0.001
1/64	1/32	0.002
1/32	1/16	0.003
1/16	1/8	0.005
1/8	1/4	0.008
1/4	5/16	0.0125
5/16	3/8	0.015

Special Limits.—On all stock where the above commercial variations are not permissible limits shall be specified in the order.

THE DISCUSSION

CHAIRMAN BACHMAN:—I have here a communication from Mr. Parrock in the Division, in which he states: "Specification No. 64, the elongation of 8 per cent is high; we recommend 4 per cent minimum. Specification No. 65:

in view of the fact that this bronze is generally chilled, the elongation of 10 per cent is high; it should read 5 per cent minimum. General: we still believe that yield-points should be omitted on all tests of brasses and bronzes and the specifications confined to tensile strength and elongation.

MR. WOODWARD:—It appears to me that the minimum elongations given in the report should be able to meet with good sound practice. They have been accepted by other manufacturers as possible to obtain.

MR. AULL:—Such criticisms as these were advanced and discussed at the meetings of the Division.

CHAIRMAN BACHMAN:—As a matter of information, I might say that my records here show that the Division voted: seven for; none against, and one not voting, with regard to these particular recommendations, Nos. 64 and 65.

R. O. SPERRY:—Referring particularly to Specifications Nos. 62 and 64, it seems to me that in widening the limits, particularly for copper and tin, we are asking the engineers to surrender a great deal. What we are attempting to do is to approximate perfection and I do not see the occasion for changing the old specifications.

MR. AULL:—The reason for changing is that a variation of 1 per cent either way in the copper is too close for average foundry practice. What we are trying to do is to get a good practical specification and at the same time one which is sufficiently scientific.

MR. SPERRY:—Has complaint ever been registered by the users as to the old specifications?

MR. AULL:—I do not know, but I doubt if the old specifications were ever used to any extent.

MR. SPERRY:—I think that in the automotive field specification No. 26 has been used generally.

MR. AULL:—Perhaps it has, Mr. Sperry, but do you think it has ever been closely adhered to? Have manufacturers asked the foundryman to live up to it exactly?

MR. SPERRY:—I think they have.

MR. AULL:—We have never been asked to live up to it. The changes in specification No. 70 as printed are rather numerous. The stencil report accompanying the printed report requires some corrections, but is the report approved by the Division. Following the Temper and Anneal Table, the American Society for Testing Material Brinell Hardness Table should be added; and preceding the table at the end of the specification, the note reading, "The average of Tension Tests of two samples of cold-rolled brass thinner than 0.080 in. shall conform to the following minimum requirements" should he added.

We recommend changing the word "physical" to "mechanical" in the side head "Physical Requirements." I understand from the Bureau of Standards that "Mechanical Requirements" is more correct than "Physical Requirements."

MR. WOODWARD:—Yes, and I think the same change can be applied to other specifications also.

MR. AULL:—In the tables of Thickness Tolerances a correction is required in the gage numbers which should be "from 15 to 18." The next line should be "from 19 to 24" and the decimal sizes should be changed from 0.0359 to 0.0403 in. and from 0.0320 to 0.0359 in. respectively to correspond with the corrected gage numbers. These are changes in detail to bring the specifications in line with the American Society for Testing Materials specifications. There is no controversy involved, simply a matter of detail to be straightened out in the report.

T. C. MENGES:—I notice in the babbitt specifications that no babbitt is recommended that is used in stationary engine practice. The amount of tin in any of the babbitts recommended is about 60 per cent, or a babbitt with about 5 per cent of tin. The stationary engine builders use babbitt having about 20 per cent of tin. I would like to see a babbitt recommended having about 20 per cent tin for this class of product.

MR. AULL:—I suggest that this be referred to the Society by letter so that it may be referred to the Non-Ferrous Metals Division in a regular manner.

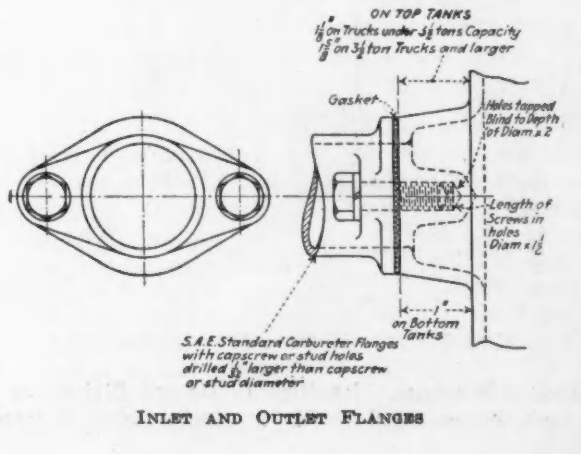
RADIATOR DIVISION REPORT

(26) *Cast Radiators*

The Radiator Division of the Standards Committee which was organized in 1920 to develop standards for use in general practice has prepared a number of recommendations which it is believed will be of value to the manufacturers of engine cooling equipment and to designers of automobiles, trucks and tractors. There are at present many differences in radiator mountings, fittings and arrangements which it is felt can and should be made standard. The recommendations reported have been carefully prepared by the Division and approved for adoption in order to bring together these many differences as new equipment is developed and brought into production. The proposed standards, when effective, will permit of conservation of materials, manufacturing equipment and stock as well as more satisfactory service to customers. They are intended to serve as approved guides to vehicle designers and builders which will in many ways lead to better and more economical practice.

Inlet and Outlet Flanges.—In present practice many tanks are cast with inlet and outlet fittings integral. This causes more expensive production, relatively high loss due to breakage and more bulky crating in shipment. Many tanks are equipped with various bolted-on fittings furnished by the customer, and uniform practice is expected to eliminate much trouble in securing and using fittings by providing a simple and suitable standard type. The Division recommends that

> Radiator inlet and outlet fittings shall be cast separate from the radiator tank. They shall be attached to the tanks by flanges which shall conform to the present S.A.E. Standard two bolt type carbureter flanges of the 1, 1¼, 1½, 1¾ and 2-in. sizes. The finished face of the pad cast on the radiator tank shall extend ⅛ in. outside of any other projection on the tank. The drilled holes in the fittings shall be 1/32 in.



INLET AND OUTLET FLANGES

larger in diameter than the capscrew or stud diameter. The tapped holes in the pad on the tank shall be blind with a maximum tapped depth of two times the capscrew or stud diameter. The length of the capscrews or studs in the tapped holes shall be 1½ times the diameter.

Overflow Tubes.—In order to secure uniform practice in the sizes of tubing used for and the method of attaching overflow tubes in the bottom tank, it is recommended that

> In tubular radiators having internal overflow tubes, the tubes shall be of seamless brass or copper, attached to the bottom tank by ½ in. American standard pipe thread brass plugs. The jacket tube shall be ⅝-in. diameter and the overflow tube shall be ⅜-in. diameter.

In order to effect manufacturing economies without impairing the capacity of radiator drain cocks where used, it is recommended that

> The size of the tapped hole for radiator drains shall be ⅜-in. American standard pipe thread.

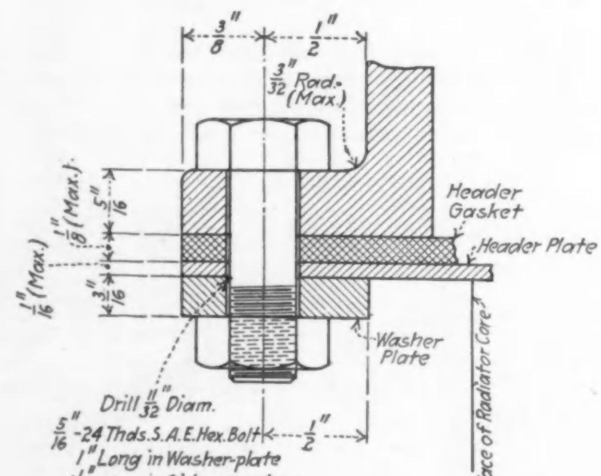
In connection with this subject, the Miscellaneous Division, at the request of the Radiator Division, is working toward the standardization of the minimum diameter of hole in the nozzle of drain-cocks. Discussion at the Radiator Division meetings indicated that this dimension varies as between different makes, in some instances being unreasonably small in proportion to the other dimensions of the drain-cocks.

Header Flanges.—General practice is in many instances nearly the same, and in order to economize in materials and manufacture, it is recommended by the Division that

> Bolt-hole centers shall be spaced 2½ in. apart wherever possible.

Tests have been conducted by members of the Division which indicated that cooling ribs or flanges on cast tanks are not particularly effective. Therefore in order to facilitate production in standard practice it is recommended that

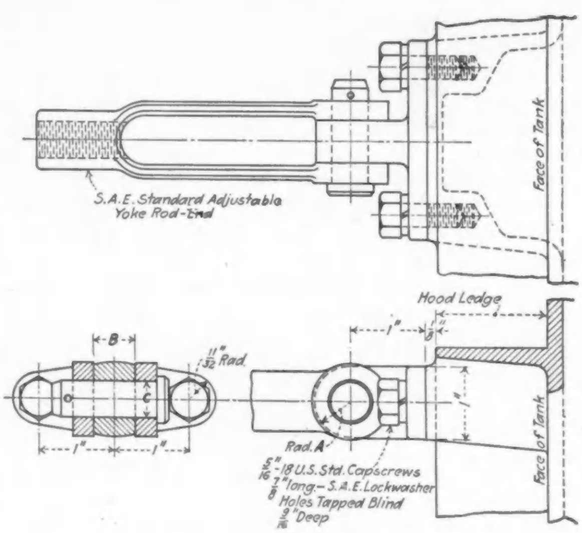
> Cast radiator tanks shall be designed without ribs or cooling flanges.



Cast Radiator Header Flange Dimensions

Tie-Rod Fittings.—Practice in tie-rod fittings on the top tank varies considerably in design, cost of production and in effectiveness. The Division recommendation is approved as being practical and economical in that it uses S.A.E. standard yoke rod-ends which are stocked by many forging manufacturers and are easily obtained. The proposed fitting is easy to manufacture and is readily removed and replaced and makes certain of bringing the top of the tank to the same position when it is reset which is necessary to prevent undue straining of the radiator shell and core. The following recommendation is therefore submitted:

> Tie-rod fittings shall be in accordance with the accompanying illustration.



Cast Radiator Tie-Rod Fittings

Nominal Truck Capacity, Tons	A	B	C +0.001 −0.002
To 4 inclusive	11/32	7/16	3/8
Over 4	15/32	9/16	1/2

Radiator Tests.—When the Division was considering this matter it was stated that leakage tests, especially as conducted by many radiator purchasers, vary from 2 to 25 lb. pressure. The higher pressures frequently cause leaks and lead to excessive rejection of radiators. The experience of the Division members indicates that the recommended practice is ample to indicate any leaks due to defective manufacture. It is therefore recommended that

> A pressure of 5 lb. per sq. in. shall be used in making all tests for radiator leaks.

Header-Plate Widths.—Comparison of widths of stock used for header-plates indicates that practically all sizes can be cut economically from the following sheets, which will facilitate the purchase and stocking of this material. It is therefore recommended that

> Header-plate widths shall be 5, 5½, 6, 6½ and 7 in.

Hood-Ledge Widths. — Compilation of data of the hood-ledge widths used on different makes of trucks indicates variation in practice which is not considered necessary. It is felt that the following recommendation is good practice for manufacturing and operation, and that it is desirable to standardize this feature, since it more or less controls the height of the water inlet and

tie-rod pads cast on the top tank, and which are generally faced on a disk grinder.

> The hood-ledge on cast radiators shall be 1 in. wide on motor trucks having a nominal capacity of less than 3½ tons, and 1½ in. wide on motor trucks having a nominal capacity of 3½ tons or more.

(27) *Passenger Car Radiators*

Radiator Mountings.—As passenger car radiators are usually mounted rigidly in the car frame, a flexible tie-rod is recommended to prevent straining the radiator shell through "weaving." It was felt that a more definite specification for the tie-rod or fastening should not be attempted at this time for passenger cars, but that a general guide should be provided against using non-flexible radiator supports.

> The tie-rod connecting the body (dashboard) and the top of the radiator shall be flexible.

Hood-Ledges and Hood Lacings.—General practice for the hood-ledge and lacings for passenger cars is in general fairly uniform although not always as wide as is now recommended. It is felt that the proposed minimum width should be maintained so as to give ample support to the hood, and also provide for sufficient clearance between the edge of the hood and the radiator shell to prevent rubbing or punching the shell when the hood gets out of shape or through "weaving" in the car frame.

> The hood-ledge shall have a minimum width of ⅞ in. Hood lacing shall be not less than ⅜ in. wide and not less than ⅛ in. thick.

TIRE AND RIM DIVISION REPORT

(28) *Wood Felloe Dimensions for Pneumatic Tire Rims*

In order to have the present standard list of felloe-band sizes conform to the S.A.E. Standard sizes of pneumatic tires and rims, the Tire and Rim Division's recommendation to extend the present standard to include the 34 x 5-in. wood felloe having a width of 2½ in. and a depth of 1⅝ in. plus or minus 1/16 in. was approved for adoption.

TRACTOR DIVISION REPORT

(29) *Tractor Belts and Pulleys*

As the Tractor Division believes pulleys of smaller than 8-in. diameter are not to be recommended for tractor purposes because of the high belt tension required to prevent excessive slippage, the Division has recommended that the present S.A.E. Standard for Tractor Belts and Pulleys, page K40, S.A.E. HANDBOOK, Vol. I (new edition), be revised to conform to the following:

> **Belt pulleys and clutch diameters for new equipment shall not be less than 12 in. and the pulley width shall not be less than ½ in. wider than the belt required.**
>
> **Tractor drive belts for all purposes shall be 5, 6, 7, 8 or 9 in. in width.**

This recommendation was approved for adoption.

THE DISCUSSION

E. A. JOHNSTON:—In addition to the printed report of the Tractor Division I would like to say that the Tractor Subdivisions have been very active and accumulated considerable data. Very little of the work has, however, been completed. The Subdivision on Plowing Speeds ran tests continuously during the past summer, as long as the weather would permit, several hundred tests having been made.

(30) *Tractor Engine Governors*

Experience, such as the bursting of threshing machine cylinders due to speeding up of the engines when not equipped with governors when the load was reduced or taken off entirely, has indicated the danger of operating such apparatus without a governor. The Tractor Division has recommended as a guide toward good engineering practice that the following be adopted as S.A.E. Standard:

> **Farm tractors and engines intended for belt operation shall be equipped with a governor. It is suggested that they should also be so designed that a suitable speed indicating device may be attached.**

This recommendation was approved for adoption.

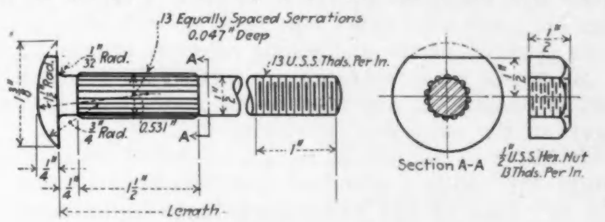
THE DISCUSSION

MR. JOHNSTON:—The reason for the proposed standard for Tractor Engine Governors is that on implements run by a tractor that is not equipped with a governor, the cylinders and cutting wheels will burst when the speeds are excessive; and on many tractors there is no space in which to attach a speed indicator, so that no provision is made in designing the tractor to get the speed of the engine.

TRUCK DIVISION REPORT

(31) *Rim Clamp Bolts*

The standard rim clamp-bolt adopted by the Society in August 1920 has a full-round head. The practice in assembling has been to drive the clamp-bolt home so that one edge of the head is turned up over the under edge of the felloe band on wood wheels or a shoulder turned in the felloe of metal wheels. This is not considered best practice, especially on wood wheels, as the necessary force required to turn up the edge of the bolt head tends



RIM CLAMP-BOLTS

to disturb the wood felloe and to bend the whole head of the bolt instead of the edge of the head. A Subdivision which has investigated this practice reported to the Truck Division its proposed revision as printed above. The Truck Division has considered this proposal and recommended its adoption by the Society as the standard clamp bolt for pneumatic-tire rims, on both wood and metal wheels as original and service equipment.

The recommendation was approved for adoption.

THE DISCUSSION

RUSSELL HOOPES:—I think that for the old type of bolt, the inner face of the wood felloe has been nearly flush with the edge of the felloe band so that the edge of the bolt head does not bend down. If this new standard, which I deem is good, is adopted, the width of the wood felloe will have to be reduced so that the bolt head will go underneath the felloe band and keep it from turning.

MR. BRUMBAUGH:—This matter was brought up by the use of the same bolt in wood or metal wheels. The thickness of the wall in the metal wheels is relatively so small that the ¼-in. dimension between the serrations and the

head of the bolts, which is necessary in their manufacture, leaves practically no provision for holding the bolts from turning in metal wheels, unless some grip on the head is obtained. The proposal affords an advantage in metal wheels and yet does not make the bolts less serviceable in wooden wheels.

C. C. CARLTON:—I think Mr. Hoopes is correct in his statement that this would require a decrease in the width of the wood felloe. I have always objected to the type of bolt that the Truck Division is objecting to. When it was put into use by the rim companies, I objected strenuously. They said that it was necessary to hold the bolt, but I think this is a very much better type.

MR. BRUMBAUGH:—It does not seem to me that it is necessary to make the wood felloe narrower, because dependence is placed on the grip of the serrated portion of the bolt in the wood felloe.

MR. CARLTON:—Not entirely.

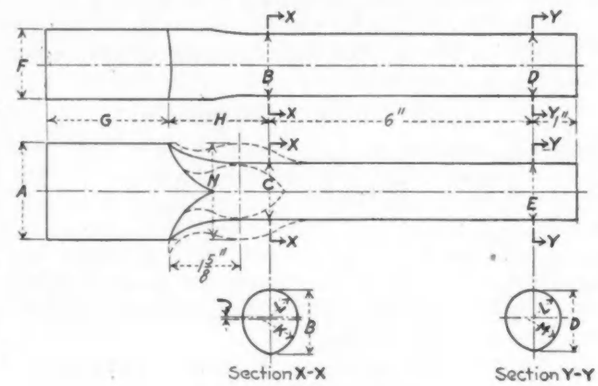
J. G. SWAIN:—Serrations are put on the bolt, not to keep it from turning, but to keep it from backing out of the wood felloe. The bolt heads, as they are now made, are perfectly round and the method of applying them is to give the bolt a hard blow after it is in the wheel, so as to upset the edge of the bolt-head and lock it under the rim or felloe band. That practice has been followed with very good success. We considered this form of bolt at the time that we arrived at a standardization of bolts for giant pneumatic rims. Our objection to it was that if in starting a bolt into a wooden wheel the square side of the bolt-head is not set in a proper angular position to go under the felloe, these flutes will cut grooves in the bolt-hole in the felloe, and when the bolt is redriven after once taking it out, it will take up the same position as before. We have found that if the round-headed bolt is used it does not make any difference how it is driven in; that when it finally reaches the seating position and it is given this extra blow, it will be set. I agree with all that has been said about this type of bolt being a little more positive as far as locking effect is concerned, and if the wheel manufacturers are willing to accept a bolt that is chamfered off, there is no doubt that manufacturers of the bolts will furnish them.

MR. BRUMBAUGH:—The flat on the bolt-head is of such height that with a standard distance between the bolt and the edge of the felloe-band there is practically a 1/16-in. clearance. We have however been considering principally the wood wheel here. The metal wheels have a shoulder turned on them for this purpose, into which the flattened faces fit. This makes the same bolt equally efficient for both kinds of wheel.

A. J. SCAIFE:—Since the Truck Division meeting in December I have worked with peculiar interest on this problem in connection with both wood and steel wheels, and I find that the edge of the bolt-heads does not bend, but that the end of the bolts bends. We tried bolts on steel wheels without cutting the heads and driving them in to get an offset on the head, but the clamps come loose. We had two cases where the felloe bands left the wheels and went over the bank.

(32) *Wood Spokes for Passenger Car Wheels*

In August 1918 the Society adopted a standard for wood spokes for motor truck wheels in accordance with those used by wheel manufacturers and endorsed by the Automotive Wood Wheel Manufacturers Association. In order to complete the standards for wheel spokes the Truck Division's recommendation of the following dimensions for passenger car wheel spokes has been approved for adoption as S. A. E. Standard. These dimensions also conform with those endorsed by the Automotive Wood Wheel Manufacturers Association and it is understood are used by practically all wood wheel manufacturers.



PASSENGER CAR WHEEL SPOKES

Nominal Spoke Size	A	B	C	D	E	F	G	H	J	K	L	M	N
$1^1/_4$	See Table Below	$1^7/_{32}$	$1^1/_{32}$	$1^3/_{16}$	$1^1/_{32}$	$1^1/_2$	$2^3/_4$	$2^1/_4$	$^1/_{32}$	$^{19}/_{32}$	$^1/_2$	$^{11}/_{16}$	$1^{25}/_{32}$
$1^3/_8$		$1^5/_{16}$	$1^3/_{32}$	$1^1/_4$	$1^3/_{32}$	$1^{23}/_{32}$	$2^3/_4$	$2^1/_4$	$^1/_{32}$	$^{25}/_{32}$	$^{17}/_{32}$	$^3/_4$	$1^{27}/_{32}$
$1^1/_2$		$1^7/_{16}$	$1^7/_{32}$	$1^3/_8$	$1^7/_{32}$	$1^{27}/_{32}$	3	2	$^3/_{64}$	$^{13}/_{16}$	$^{19}/_{32}$	$^{25}/_{32}$	$1^{15}/_{16}$
$1^3/_4$		$1^{11}/_{16}$	$1^{11}/_{32}$	$1^5/_8$	$1^{11}/_{32}$	$2^1/_{16}$	3	2	$^3/_{32}$	$1^3/_{16}$	$^{21}/_{32}$	$1^5/_{32}$	$2^3/_{32}$

All dimensions in inches.

All dimensions are for dry spokes and are computed on a basis of a shrinkage of $^5/_{64}$ in. per in. on all green dimensions, except length dimensions, to the nearest $^1/_{32}$ in. under.

SPOKE-HEAD WIDTHS AND FLANGES

A		10 SPOKES		12 SPOKES	
Green	Dry	Flange Diameter, Maximum	Boss Bolt-Circle Diameter	Flange Diameter, Maximum	Boss Bolt-Circle Diameter
2	$1^{27}/_{32}$	$5^1/_4$	$8^1/_4$	$6^1/_4$	$9^1/_4$
$2^1/_8$	$1^{15}/_{16}$	$5^1/_2$	$8^1/_2$	$6^1/_2$	$9^1/_2$
$2^1/_4$	$2^1/_{16}$	$5^3/_4$	$8^3/_4$	7	10
$2^3/_8$	$2^3/_{16}$	6	9	$7^1/_4$	$10^1/_4$
$2^1/_2$	$2^9/_{32}$	$6^1/_4$	$9^1/_4$	$7^3/_4$	$10^3/_4$
$2^5/_8$	$2^{13}/_{32}$	$6^1/_2$	$9^3/_4$	8	$11^1/_4$
$2^3/_4$	$2^{17}/_{32}$	7	$10^1/_4$	$8^1/_2$	$11^3/_4$
$2^7/_8$	$2^{21}/_{32}$	$7^1/_4$	$10^1/_2$	$8^3/_4$	12
3	$2^3/_4$	$7^1/_2$	$10^3/_4$	$9^1/_4$	$12^1/_2$

All dimensions in inches.

UNACCEPTED RECOMMENDATIONS

In addition to the foregoing Division recommendations which were approved, a number of others were either referred back to Divisions for further consideration or definitely rejected. These are given below with the discussion at the Standards Committee meeting.

ELECTRICAL EQUIPMENT DIVISION

Magneto Couplings—Flexible Disc

The subject matter of the proposed extension of the present standard as reported by the Electrical Equipment Division and referred back to it at the Standards Committee meeting on Jan. 11 is as follows:

> Cupped or a similar form of grip-washers shall be used on the flange bolts on each side of the disc to reenforce the material against tearing out.

THE DISCUSSION

F. W. ANDREW:—This matter concerns particularly a flexible disc of the rubber type. I think this is the only case in all our standards where we practically indicate to the trade that they should use a certain type of coupling and I think that this is against the policy of the Society.

That we have had some trouble with this coupling is evident from the report that we are called upon to vote on, and under the circumstances we should eliminate the whole existing standard and substitute something of this character: The length overall of magneto couplings shall be $2\frac{3}{8}$ in. and the diameter overall shall not exceed $2\frac{3}{4}$ in. By so doing we will not be putting ourselves in the position of recommending any particular type of coupling. I think that the matter should be put in that form rather than in the form shown.

MR. LIBBY:—I think the recommendation ought to be referred back to the Division. Mr. Andrew has raised some points that were not considered by it at the last meeting.

MR. CRANE:—I do not see why we cannot standardize the dimensions of a flexible-disc type of coupling, provided it is used. I think the Society would be very remiss if we did not do so. If we want to go further and specify limiting dimensions for any and all types of coupling, I think that is an excellent thing to do, but the fact that so many people do use flexible-disc couplings makes it very desirable that they should all be alike. I should regret very much to see the standardization of the flexible disc removed at this time or at any time.

MR. LIBBY:—In answer to Mr. Crane's remarks, I would say that we have a standard which gives the diameter of the disc and the location of the bolt-holes. Some criticism of the standard arose because certain types of discs pulled out around the bolt-holes. In order to eliminate that trouble, this recommendation was made, with the addition of these three lines to our present standard as it already exists. As I understand Mr. Andrew's remarks, he would change the dimensions that we have already in the Handbook. Before doing that I think the subject ought to be reconsidered by the Division.

MR. CRANE:—I understood Mr. Andrew to take the ground that the flexible-disc type of coupling was in some way singled out as a special feature and that it should be deleted from the S. A. E. Handbook, substituting a standard giving the length overall and the outside diameter only for any type of coupling.

MR. ANDREW:—The point I wished to make is that the recommendation seems to put the Society in the position of favoring a certain type of coupling, in view of the fact that no other types of coupling are shown, whereas there are other good types. It is evident from the report presented here that there has been some trouble with the disc type of coupling, and the present standard leads people to believe that this type of coupling is the one recommended by the Society.

MR. LIBBY:—Mr. Andrew, would not the present standard be good in connection with any type of coupling?

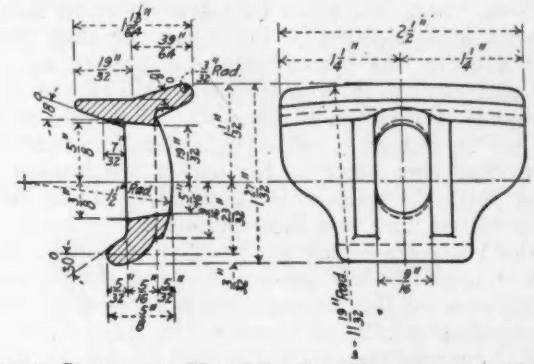
MR. ANDREW:—Not the types I have in mind, and I think we should not show one particular type only. It would be much better to give the limiting dimensions for all types.

CHAIRMAN BACHMAN:—I think that in view of the opinions expressed the matter should be referred back to the Division for further consideration.

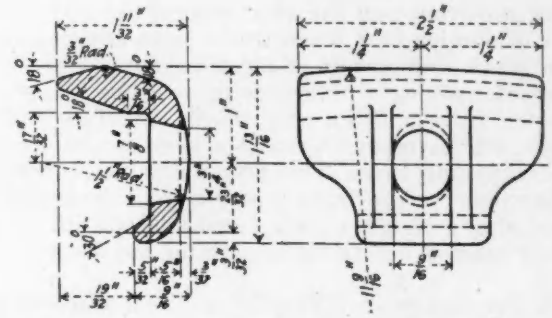
TRUCK DIVISION

Rim Sections and Contours for Pneumatic Tires

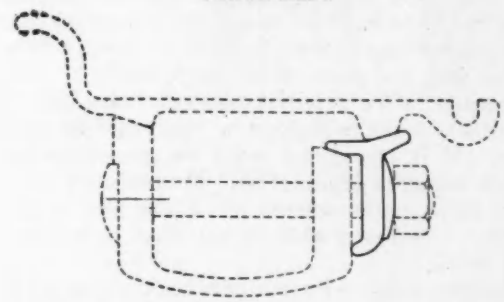
The substance of the proposal made by the Truck Division and referred back to it at the Standards Committee meeting on Jan. 11 is shown in the accompanying drawings.



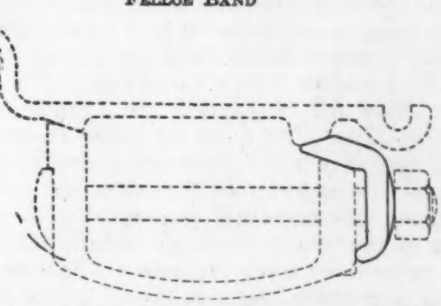
EMERGENCY CLAMPS FOR 38 x 7-IN. RIM MOUNTED ON A 36 x 6-IN. FELLOE BAND



EMERGENCY CLAMPS FOR 38 x 7-IN. RIM MOUNTED ON A 40 x 8-IN. FELLOE BAND



CROSS-SECTION OF A 38 x 7-IN. RIM MOUNTED ON A 36 x 6-IN. FELLOE BAND



CROSS-SECTION OF A 38 x 7-IN. RIM MOUNTED ON A 40 x 8-IN. FELLOE BAND

THE DISCUSSION

J. G. SWAIN:—The Tire and Rim Division considered various designs of appliances which it thought might be used to interchange different sized rims on the same wheel. There is the possibility of double oversizing of tires in using the clamps recommended by the Truck Division. This is objectionable. We have tried out clamps of this type and know from experience that they are not practical.

Consider the loading that comes on the $\frac{1}{2}$-in. clamp bolt. I think it safe to say without having any definite figures that the total load on the wheel would be thrown on

two ½-in. bolts. We know that every bolt on that wheel will bend with a clamp of that type and that the truck driver will run the chance of ruining every bolt in the wheel and having to replace the bolts. If one of those bolts bends, the rim will come off. We want to recommend to the industry only things that are practical. I believe that this recommendation is impractical in its present form. I think that it would be much better to refer it to the Tire and Rim Division.

I might say on behalf of the Tire and Rim Division that it appreciates the demand for and the necessity of arriving at some interchangeability between giant pneumatic rims as quickly as possible. In its analysis of the subject it reached the conclusion that the design of trucks which carry demountable giant pneumatic rims and tires has not progressed to a stage of definite proportions of load on the front and the rear wheels. It was the consensus of opinion that when trucks have approximated a design which will permit of using only two sizes of tire on a truck, making a difference of only one tire size between the front and the rear wheels, the Tire and Rim Division will be ready to report a very practical method of interchanging rims. This proposal of the Truck Division provides for the truck owner having three different sizes of rim, a 40 x 8, a 36 x 6 and a 38 x 7 in. I think we have started out to do something but have not yet done it.

A. K. BRUMBAUGH:—There is but one disturbing point in Mr. Swain's remarks in that he says he has tried this type of lug, and that it has not proved successful. I think we ought to have more enlightenment on that point. To what extent was it tried? Was it tried in this form? And what was the purpose of the trials?

MR. SWAIN:—We tried it several years ago, in fact several times in the past four or five years on passenger-car rims. If it would not work on passenger-car rims, it will not work on truck rims. It was used on 7/16-in. bolts, six bolts to the wheel. If it was not successful in that form, it is reasonable to say that it will not work out on a truck.

MR. BRUMBAUGH:—To me personally that is not conclusive. It must be kept in mind that this proposal is intended absolutely for use as an emergency measure, to enable a man to get home or to a service station and not be forced to stand on the road for five or six hours until somebody can come with a spare tire. It is impossible to furnish space for two spares on a truck equipped with pneumatic tires. There is no spare room and there is also the matter of the investment in two tires. It is true that these clamps have not been tried out extensively, but the subject was carefully considered at a well attended meeting of the Truck Division, comprising among others several prominent truck engineers. Sample wheels were provided and there were no flaws in the proposal that could be pictured. It was the opinion at that meeting that the proposal is practical.

MR. SWAIN:—I have personally tried a similar arrangement in a small way; that is, on a smaller size wheel, and found it to be impractical. I would not want to be in the position of standing in the way of something that is good for the industry, and I would be very glad, and the company with which I am associated would be very glad, to make some experiments on wheels of the sizes in question to determine whether the recommendation of the Truck Division is practical. I suggest that before this is placed in our hands as recommended practice, we actually try it out and ascertain whether it is right. I can say on behalf of one of the companies manufacturing rims that we would be reluctant to see a proposition like this go out into practice, and we would not want to stand behind it.

GEORGE L. LAVERY:—I have made a set of these clamps and put them on wheels and tried them. I know that they do work satisfactorily. It is a fact that the bolts can become bent, but there will be no more bolts bent than in the present use of the locking rim on the standard forms of wedge rim, with which bolts will become bent in 40 per cent of the cases.

I tried the rims on a 2-ton truck and ran it for about two hours with entirely satisfactory results. There has not been time enough to try the matter out in an extensive way. It is, as Mr. Brumbaugh states, a purely road emergency proposition. If a set of bolts were lost it would not be very expensive to replace them.

MR. BRUMBAUGH:—A condition exists now with trucks operating on pneumatic tires and we must provide something and provide it quickly. If this proposal is somewhere near practical—and Mr. Lavery's trial of it seems to reinforce that opinion—it should be given favorable consideration at least.

C. C. CARLTON:—I am most heartily in favor of anything that will accomplish the purpose for which the clamp is intended. I wonder, however, if the Society wishes to put itself in the position of going through the formality of adopting a thing of this sort as a recommended practice. It seems to me that this is largely a matter of Society policy. If we open the gates by adopting this apparently untried proposition, which I should like very much to see tried and which I am very heartily in favor of if it is practical, I think we are treading on rather dangerous ground.

CHAIRMAN BACHMAN:—The Standards Committee is supposed to act as a check on the work of the Divisions and the members have in their hands the safeguarding of the policy of the Society.

Hubs—Wood and Metal Wheels

The proposal which was referred back to the Truck Division at the Standards Committee meeting on Jan. 11 is set forth in the accompanying drawings and tables.

BEARINGS FOR PROPOSED STANDARD MOTOR TRUCK FRONT HUB

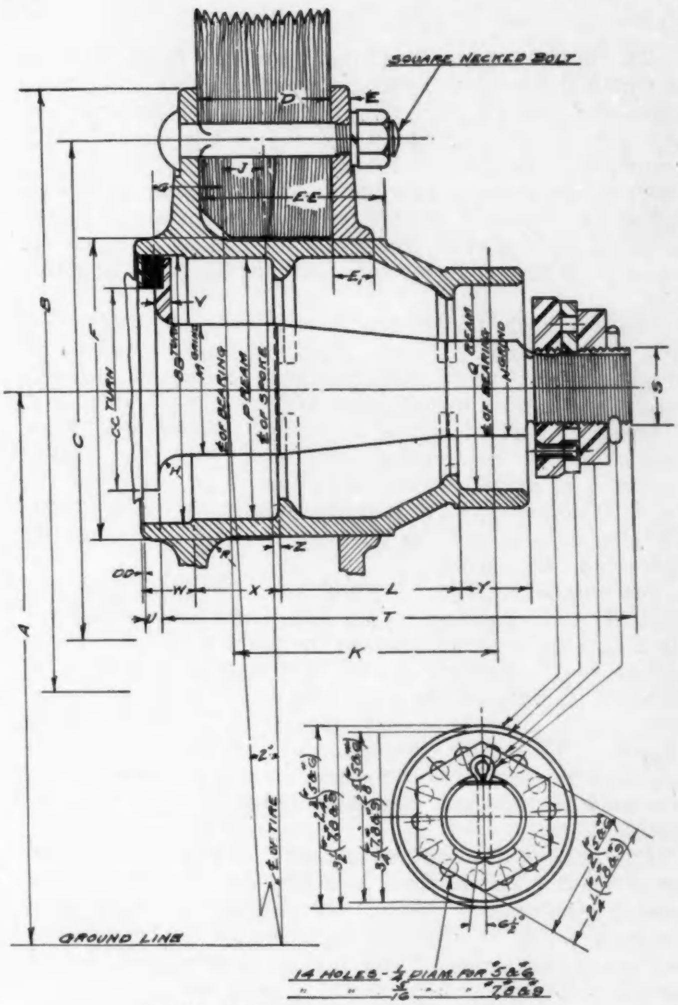
Spindle Number	Bearing	Bock Bower, Gilliam, Timken		Proposed Standard Width	Bock Bearing and Width	Bower Bearing and Width	Gilliam Bearing and Width	Timken Bearing and Width
		Bore	O. D.					
5	Inner	1.7500	3.4843	1.5000	435-43 1.5000	435T 1.5000	435-4320 1.5000	435-4320 1.5000
	Outer	1.1875	2.8593	1.1875	3191-3110 1.1875		3191-312 1.1875	3191-3120 1.1875
6	Inner	2.000	3.9843	1.5000	455-45 1.5000*	455T 1.5000*	455-4520 1.5000*	4580-4524 1.5000§
	Outer	1.5000	3.1562	1.15625	3381-3310 1.1875†		3381-3320 1.15625	3381-3320 1.15625
7	Inner	2.1250	4.3750	1.5000	539-53 1.5000	539T 1.5000	539-532 1.5000	539E-532 1.5000
	Outer	1.7500	3.4843	1.5000	435-43 1.5000	435T 1.5000	435-4320 1.5000	435-4320 1.5000
8	Inner	2.5000	4.7343	1.7500	5564-5500 1.7500	5564T 1.7500	5564-553 1.7500	5584E-5520 1.7500
	Outer	2.000	3.9843	1.5000	455-45 1.5000*	455T 1.5000*	455-4520 1.5000*	4580-4524 1.5000
9	Inner	2.5625	5.1875	2.1250	6379-6310 2.1250			6379-6321 2.1250
	Outer	2.000	3.9843	1.5000	455-45 1.5000*	455T 1.5000*	455-4520 1.5000*	4580-4524 1.5000

All dimensions in inches.
*A new bearing now manufactured.
†Bock will decrease width to 1.15625 in.
§New bearing proposed by Timken.

PROPOSED DIMENSIONS FOR WOOD WHEEL HUBS

Hub and Spindle Number	Letter	5	6	7	8	9
Ground to Center Line of Hub	A	17	18	18	18	18
Diameter of Flange	B	8 1/2	9 1/4	10	10 3/4	11 3/4
Flange Fillet Radius	R	3/8	1/2	5/8	3/4	3/4
Bolt-Circle Diameter	C	6 3/4	7 1/2	8 1/4	8 3/4	9 3/4
Number of Flange Bolts	....	12	12	12	12	12
Diameter and Length of Bolts	....	1/2x3	1/2x3 1/4	1/2x3 3/4	5/8x4	5/8x4 1/2
Spoke Thickness Between Flanges	D	1 3/4	2	2 1/4	2 1/2	2 3/4
Thickness of Loose Flange At O. D.	E	1/4	5/16	3/8	3/8	7/16
Thickness of Loose Flange At Bore	E_1	1/2	5/8	3/4	7/8	1
Wheel Bore Limits for Hub	F	4.025 4.005	4.525 4.505	5.025 5.005	5.390 5.370	5.900 5.880
Spindle Shoulder to Center Line of Inner Bearing	G	7/8	1 1/16	1 1/8	1 3/8	1 1/2
Spindle Fillet Radius	H	1/4	5/16	5/16	3/8	3/8
Center Line of Inner Bearing to Center Line of Spoke	J	5/8	5/8	5/8	5/8	5/8
Center Line of Inner Bearing to Center Line of Outer Bearing	K	3 3/4	4	4 1/4	4 3/4	5
Inner Bearing Shoulder to Outer Bearing Shoulder	L	2 9/32	2 29/32	2 5/8	3 15/3	3 15/32
Spindle Diameter Limits at Inner Bearing	M	1.7495 1.7485	1.9995 1.9985	2.1245 2.1235	2.4995 2.4985	2.562 2.561
Spindle Diameter Limits at Outer Bearing	N	1.187 1.186	1.4995 1.4985	1.7495 1.7485	1.9995 1.9985	1.9995 1.9985
Hub Bore Limits for Inner Bearing	P	3.482 3.481	3.981 3.979	4.372 4.370	4.731 4.729	5.184 5.182
Hub Bore Limits for Outer Bearing	Q	2.857 2.856	3.154 3.153	3.482 3.481	3.981 3.979	3.981 3.979
Thread on Spindle (U. S. S.)	S	1 1/8x7	1 1/8x7	1 1/2x6	1 1/2x6	1 1/2x6
Spindle Shoulder to End of Spindle	T	6 11/16	7 1/4	7 3/4	8 3/4	9 1/8
Width of Spindle Shoulder	U	1/4	1/4	5/16	5/16	5/16
Thickness of Washer	V	1/4	1/4	5/16	5/16	5/16
Width of Counterbore	W	23/32	11/16	27/32	31/32	1 1/32
End of Counterbore to Inner Bearing Shoulder	X	1 5/16	1 1/4	1 5/16	1 7/16	1 3/4
Outer Bearing Shoulder to Outer Hub End	Y	1 1/16	1 3/32	1 7/16	1 7/16	1 7/16
Center Line of Spoke to Inner Bearing Shoulder	Z	1/4	—1/32	1/16	1/16	5/16
Diameter Limits of Counter Bore	BB	3.492 3.497	3.991 3.996	4.382 4.387	4.741 4.746	5.194 5.199
Diameter Limits of Spindle Shoulder	CC	2.630 2.625	3.130 3.125	3.380 3.375	3.755 3.750	4.1925 4.1875
Hub Overlap of Dust Ring	DD	1/32	1/32	1/32	1/32	1/32
Length of Hub Barrel	EE	2 7/16	2 13/16	3 3/16	3 9/16	3 15/16
Spindle Load Rating on Solid Tire at Ground in Pounds	....	1250	1625	2125	2750	3500
Width and Thickness of Wood Felloe*	....	2 3/4x1 1/2	3 1/4x1 5/8	4 1/4x2	5 1/4x2	6 1/4x2
Outside Diameter and Thickness of Felloe Band*	....	28x5/16	30x5/16	30x3/8	30x3/8	30x3/8
Number of Spokes in Wood Wheel	....	12	12	12	12	12
Load Rating of Wood Wheel in Pounds	....	1350	1800	2650	3500	4500
Solid Tire Size*	....	34x3 1/2	36x4	36x5	36x6	36x7
Solid Tire Load Rating in Pounds*	....	1300	1700	2500	3300	4200

*S. A. E. Standard

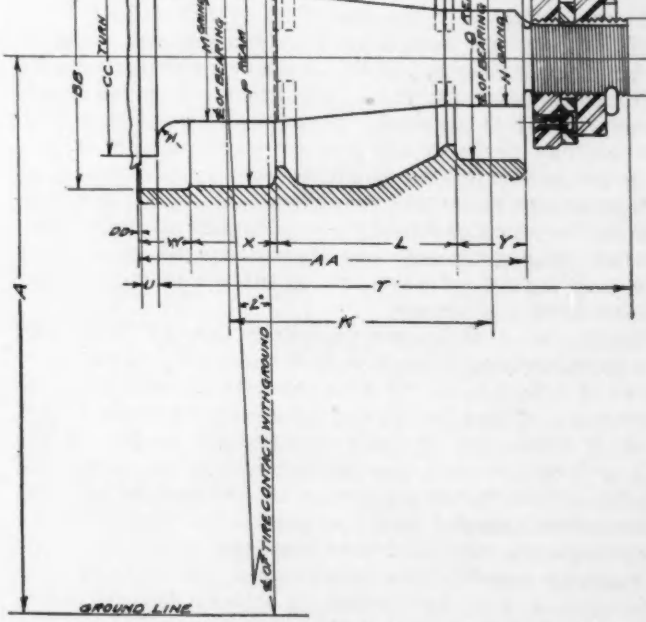


MOTOR TRUCK WOOD WHEEL HUBS

PROPOSED DIMENSIONS FOR METAL WHEEL HUBS

Hub and Spindle Number	Letter	5	6	7	8	9
Spindle Load Rating on Solid Tire at Ground in Pounds	....	1250	1625	2125	2750	3500
Solid Tire Size*	....	34x3 1/2	36x4	36x5	36x6	36x7
Solid Tire Load Rating in Pounds*	....	1300	1700	2500	3300	4200
Ground to Center Line of Hub	A	17	18	18	18	18
Spindle Shoulder to Center Line of Inner Bearing	G	7/8	1 1/16	1 1/8	1 3/8	1 1/2
Spindle Fillet Radius	H	1/4	5/16	5/16	3/8	3/8
Center Line of Inner Bearing to Center of Line of Tire	J	5/8	5/8	5/8	5/8	5/8
Center Line of Inner Bearing to Center of Line of Outer Bearing	K	3 3/4	4	4 1/4	4 3/4	5
Inner Bearing Shoulder to Outer Bearing Shoulder	L	2 9/32	2 29/32	2 5/8	3 15/32	3 15/32
Spindle Diameter Limits at Inner Bearing	M	1.7495 1.7485	1.9995 1.9985	2.1245 2.1235	2.4995 2.4985	2.562 2.561
Spindle Diameter Limits at Outer Bearing	N	1.187 1.186	1.4995 1.4985	1.7495 1.7485	1.9995 1.9985	1.9995 1.9985
Hub Bore Limits for Inner Bearing	P	3.482 3.481	3.981 3.979	4.372 4.370	4.731 4.729	5.184 5.182
Hub Bore Limits for Outer Bearing	Q	2.857 2.856	3.154 3.153	3.482 3.481	3.981 3.979	3.981 3.979
Threads on Spindle (U. S. S.)	S	1 1/8x7	1 1/8x7	1 1/2x6	1 1/2x6	1 1/2x6
Spindle Shoulder to End of Spindle	T	6 11/16	7 1/4	7 3/4	8 3/4	9 1/8
Width of Spindle Shoulder	U	1/4	1/4	5/16	5/16	5/16
Thickness of Washer	V	1/4	1/4	5/16	5/16	5/16
Width of Counterbore	W	23/32	11/16	27/32	31/32	1 1/32
End of Counterbore to Inner Bearing Shoulder	X	1 5/16	1 1/4	1 5/16	1 7/16	1 3/4
Outer Bearing Shoulder to Outer Hub End	Y	1 1/16	1 3/32	1 7/16	1 7/16	1 7/16
Center Line of Tire to Inner Bearing Shoulder	Z	1/4	—1/32	1/16	1/16	5/16
Overall Length of Hub	AA	5 3/8	5 15/16	6 7/32	7 5/16	7 11/16
Diameter Limits of Counterbore	BB	3.492 3.497	3.991 3.996	4.382 4.387	4.741 4.746	5.194 5.199
Diameter Limits of Spindle Shoulder	CC	2.630 2.625	3.130 3.125	3.380 3.375	3.755 3.750	4.1925 4.1875
Hub Overlap of Dust Ring	DD	1/32	1/32	1/32	1/32	1/32

*S. A. E. Standard.



MOTOR TRUCK METAL WHEEL HUBS

THE DISCUSSION

MR. BRUMBAUGH:—The meeting of the Truck Division at which this proposed recommended practice was passed upon was held on Dec. 16. In the short time that was available to get the printed report into the hands of this Committee the subject matter and explanation of the proposal were prepared very hurriedly. The recommendation for standard front-wheel hubs is but a part of the program instituted at the request of and an insistent demand from the trade for some standardization along this line.

The program for motor-vehicle hub standardization was inaugurated in June, 1920, by representatives of wood and metal wheel manufacturers in cooperation with manufacturers of axles, hubs, bearings, rims and tires. It has been carried out by a special Committee of Five, four of whom are representatives of prominent manufacturers of axles. This Committee is not a part of the Truck Division of the Standards Committee, but is closely affiliated with it and the Wheels Subdivision through its Chairman, Mr. Myers.

The standardization of wheel hubs for front and rear axles for both passenger cars and motor trucks was too big a task to be undertaken at the same time, and it was agreed that consideration of rear-axle hubs should be deferred in favor of the front-axle hubs for motor trucks only, which afforded better opportunity for immediate progress. Following completion of this part of the program, work is expected to proceed on passenger-car front-axle hubs and then on rear-axle hubs for both types of vehicle.

It is evident that since real hub standardization depends upon bearing sizes and location, which in turn depend upon spindle design, the logical procedure is to design a series of steering spindles for load capacities that cover the range of the various motor-truck models having load capacities of from $\frac{3}{4}$ to 5 tons.

The proposed designs for the five sizes of spindles and hubs for motor trucks were laid down on the basis of definite maximum load ratings in pounds on the tires at the ground. These ratings were selected with reference to existing practice in motor truck construction, and to the load rating of the solid tire and wheel built around each spindle and hub.

In connection with the report as submitted the Truck Division does not feel that it should propose complete designs, but rather a layout of the interior and the exterior portions of the hubs. To get bearings of proper capacity in, it is necessary to carry the practice a little further than probably the Society would usually care to go in the matter of design, but to get any progress at all it is necessary to propose considerable design. The Division is therefore proposing a spindle layout with bearings and the necessary hub dimensions to meet those bearings, and an exterior hub layout which will include the fitting of the wheels.

Spindle No. 5 will serve passenger cars of from 4200 to 5500 lb. weight; Nos. 5, 6, 7, 8 and 9 will serve motor trucks of from $1\frac{1}{2}$ to $7\frac{1}{2}$ tons capacity on solid or pneumatic tires. The spindles and hubs have no other rating, however, than that of their capacity in pounds on the tires at the ground. No matter what the rated load capacity of the motor truck may be, the spindle and hub to be used will depend upon the weight distribution of the loaded vehicle, which determines the load the front wheels must carry. This weight need not be as of estimate only, as it can be checked by scales measurement.

The spindles are designed so that the center of the tire where it touches the ground is vertically under the center of the inner bearing. There is, I understand, a certain patent relating to this feature, but as it expires on March 1, 1921, there is nothing to prevent proceeding with the work.

This arrangement brings the point of contact of the tire on the ground near the projection of the steering-pivot center on the ground and makes for easy steering. For a given tread and frame width it permits a great angular movement of the front wheel and therefore a short turning circle. It also reduces to a minimum the pressure on the steering-pivot and its bushings.

The location of the tire so that the load is under the inner bearing instead of between the bearings also reduces the bending moment which is due to the vertically applied load on the spindles. In the case of many axles now in use this bending moment is three or four times as great as in the case of the accompanying proposed standard spindles.

The spindles have been designed with large fillets at the shoulder, an important feature that has often been slighted in the past. It strengthens the spindle at the point of maximum stress and has the effect of moving the shoulder toward the load line, thereby decreasing the moments by shortening the lever arm to the point of load application. General practice among axle makers is to use a low-nickel or chrome-nickel steel, such as S. A. E. No. 2340 or 3140, for spindles, but the stresses in the proposed spindles will be low enough to allow the use of S. A. E. Steel No. 1035 if it should become necessary to do so under extraordinary circumstances.

The selection of the bearings resulted from a study of the types, sizes and extent of their use for this application in the trade at this time. Figures for 1919 show that about one and a quarter million bearings were used on commercial-car and motor-truck front axles. Taper roller bearings constituted about 90 per cent, straight roller bearings constituted less than 5 per cent, and ball bearings about 5 per cent of the total.

This work was started with the intention of, if possible, establishing hub and spindle dimensions such that ball and roller bearings would interchange, but it was found that there would be difficulty in getting recommendations from the manufacturers of ball bearings and roller bearings by which such interchangeable dimensions could be developed. After careful consideration, it was thought to be reasonable to confine the proposal to roller bearing hubs.

There are at least four manufacturers of taper and straight roller bearings who can furnish interchangeable bearings for the proposed hubs.

Accomplishment of the proposed standardization would be broad in its effect, as it would ultimately retire many hub and spindle designs having small and non-essential variations and reduce the number of spindles required for a given range of motor-truck sizes.

Proper standardization will encourage improvements in wheels of all kinds, because of the volume of business available in any particular size and will help to reduce the large investment in stocks of parts carried by parts manufacturers, truck manufacturers and service stations; and a manufacturer will be able to change from one source of wheel supply to another without changing parts or necessitating an additional set of service parts should any one source of supply fail. Service stations would be able to furnish wheels which would interchange on standard spindles and bearings, so that a damaged truck wheel could be replaced at a nearby service station.

The proposed spindles have been developed in practical accordance with S.A.E. tire capacity ratings, which are pretty well in line with motor truck capacities.

The proposal would be of advantage to American truck manufacturers in foreign trade. This is an important point and should not be overlooked, for American trucks must first meet competition abroad on the basis of being American trucks versus British, French, Italian and German trucks. While service parts are of great importance in the trade at home, they are an essential feature in foreign business. Front axles are rarely a sales point here, but abroad this standardized feature can be of great use, for American trucks in which are embodied such standards could be serviced from one or a few warehouses.

A meeting of the Committee of Five was held in Detroit December 15 to which practically all manufacturers of front axles were invited and many attended. The proposal was analyzed point by point and unanimous approval had.

The Truck Division and Wheels Subdivision of the Standards Committee considered the entire proposal at a meeting held December 16 in Cleveland. A few changes were made, principally in the method of illustrating component parts of the proposal. Many compromises have been made in order to overcome differences existing in practice and attempts have been made to adjust the proposal so that it will be of benefit to the industry at large and cause the least inconvenience to any one manufacturer. It is felt that much credit is due to the many persons and companies consulted for the manner in which individual preferences have been submerged and support given to the general proposal. The rapid progress which has been possible in this work has been due largely to the valuable suggestions and important concessions made toward possible establishment of such a standard.

I would like to submit the report and move its adoption as S. A. E. Recommended Practice.

CHAIRMAN BACHMAN:—There has been a considerable demand on the part of various interests in the industry for work of this character, arising from needs of manufacturers of both wood and metal wheels, and the difficulty encountered on the part of the vehicle builder in changing from one type of wheel to the other. That is only a part of the problem; I mention it as a single illustration.

This work has been started and rather than hold up the whole situation, awaiting the completion of a complete program, which would embrace passenger cars as well as trucks, rear wheels as well as front wheels, various types of bearings which may have conflicting characteristics that make it difficult to get one design which would incorporate the desirable features of all, the committee has started by attacking what it considers to be the easiest part of the problem and the one upon which it thought most rapid progress could be made—the front wheels for trucks. Consequently, in effect this recommendation is for hubs that can be used with either wood or metal wheels, mounted on a spindle with the use of taper roller bearings.

There are various items in connection with the proposal that need careful consideration. The matter of design, which this recommendation touches on possibly more intimately than in much of our work, has to be considered in the light of the peculiar characteristics of this particular matter. It seems almost impossible to conceive of arriving at any results unless such a procedure is followed; yet it must be followed in light of the policy which has been established in the conduct of the Society's affairs. We must not allow the apparent advantages to be derived from this work to overbalance the good that has been recognized in the policy that we have followed in the past. On the other hand, we must not take such a conservative position that the benefits that can be derived by a program such as this will be thrown over, purely from the standpoint of blind adherence to precedent.

There is one matter that I will take the privilege of calling to your attention; the question of load rating. The proposed ratings seem to be a logical method by which the different sizes should be differentiated and I see no particular objection to it. However, during the past few months another condition has arisen that I want to mention. The Society adopted some time ago a table of capacities for solid tires, and certain legislatures in this country have assumed that it can be taken as the basis for legislation regulating the allowable load per inch width of tires on highways. That may be perfectly proper or it may not be. I am bringing that situation to your attention to indicate that we must be careful in some of these matters because developments follow that we do not think of at the time. It is entirely possible in this instance that the proposed spindle ratings might be made the basis of similar action by legislative bodies unless we give this matter adequate consideration and know that it is the right basis, or place something in our records to indicate exactly what we mean.

I have a communication from T. Kargau which reads as follows:

> The thread on the spindle is given as a U. S. Standard thread. This thread is in my opinion too coarse for this class of service, as there would be very few threads in each of the nuts. I believe that the S. A. E. thread would be better.
>
> The method of using lock-nuts does not conform to my ideas either, the reason for this being that the outer nut forces the inner nut in and hence in most cases the inner nut does not take any of the load whatever, as it is bearing against the opposite side of the thread. We therefore have the resistance of the outer lock-nut only. I therefore suggest the use of a tongue washer and a standard S. A. E. Castellated nut.
>
> The original report by Mr. Myers included data on wheels for pneumatic tires and I believe this should be included in the S. A. E. Recommended Practice.

C. T. MYERS:—The device offered for adoption is used by several well-known axle companies and truck builders who build their own axles. It has been in use for a number of years and has given very satisfactory service. It was adopted for this reason; not that it is necessarily the best. It is as good as any we know of. There are objections to any other type of locking device and this one seems reliable, one of the requisites in this proposal. An objection to using an S. A. E. thread on the spindle arose in that it is too fine, and it is a little difficult to get the thread in the nuts to fit the thread on the spindles. This point was taken up on a number of occasions and in each instance the S. A. E. thread was voted down, it being shown that the U. S. thread gave satisfactory service.

As to the outside nut taking all the strain, either one nut or the other will take the strain anyway. I think nobody knows which nut that is. Very likely in actual operation the two nuts are jarred loose on the spindle and the outside nut backs off until it touches the cotter-pin. Under that condition the D-washer still holds the inside nut in adjustment; it cannot turn because the outside nut cannot back off a sufficient distance to release the D-washer, and as long as the D-washer cannot turn, the

inside nut cannot turn. That will hold the nut in its proper adjustment.

The pneumatic tire situation is being canvassed. We felt that we could go only as far as our knowledge indicated it was safe to go. We believe that in all the points covered we are safe in these recommendations, and that they correspond very closely to best practice. There may be some difference of opinion, but the design as laid down allows for individual modification, to enable designers to adhere more or less to their own ideas. The pneumatic tire situation is not definitely fixed in the minds of many at the present time and we do not as yet know how we should rate the axle spindles on pneumatic tires. It is the opinion of the committee that before recommending an S. A. E. Standard we should have more experience in this connection. The indications are that we shall not have to change any essential dimensions in the hubs to use pneumatic tires properly and economically.

With regard to taper and parallel roller bearings, there are at least four makes that will interchange to within 0.0002 in. in the inside, and outside diameters and in the widths.

The question of considering ball bearing in these hubs will be brought up, and it should not be assumed that this proposed recommended practice eliminates the ball bearing from use on motor trucks. We attempted in the beginning to make the hubs interchangeable for ball and roller bearings but found it impossible to do so. We will take up this matter with the ball bearing manufacturers and with any one else who has experience on this subject, and prepare a series of hubs applying to ball bearing specifications which it will be perfectly practicable to adhere to.

The bearings selected for these hubs are those which it was thought would best fulfill the conditions to be met. It was very evident in our discussions with people who buy and use these bearings that they will use the cheapest bearings which are reliable. Not very much consideration was given to the point of cheapness in selecting these bearings, but we argued for many months over the bearings sizes, and finally reduced the list to a reasonable length. The 10 applications on the five spindles will be covered by seven sizes of bearings, which will be continued as standard production by all the companies making them.

F. W. GURNEY:—The ball bearing people, although fully appreciating the great amount of work that Mr. Myers and his associates have done, still feel that if they had been given an opportunity, which through some oversight perhaps they were not given, to present their side of the situation, they might possibly have induced the committee to at least lend the weight of its influence on the side of a single proposal for standardization of the ball and the roller bearings for such work as this. We have observed that in many of the sizes that the committee recommends, if not in all, by the use of a wide type of ball bearing, we can come within a very few thousandths of the dimensions. There has been for some time an attempt made in the Ball and Roller Bearing Division of the Standards Committee to provide a common standard for ball and roller bearings, and we feel that this is an instance in which it could very well be done. This would not mean that the committee would be recommending perhaps that any one should go to some additional expense to use ball bearings; the great advantage would be that in case of necessity a ball bearing could be interchanged with the roller bearing. You all realize that in Europe the roller bearing is much less in use than in this country. There they can more readily find in any supply house ball bearings of standard sizes.

If this recommendation is to be adopted as presented, it seems to me that the heading under which it is given should be changed to read, Roller Bearing Hubs for Wood and Metal Wheels.

H. B. KNAP:—I would like to propose an amendment to the motion to approve this report. I make this amendment on the basis that due to the haste in which the report was prepared it would have to be modified somewhat to represent the action really taken by the Truck Division on Dec. 16. The amendment reads:

> The subject matter of this proposal is to be modified before being released as recommended practice or standard, and to be in accordance with the recommendation of the Truck Division it is to be reapproved by the Truck Division at its next meeting, with the proviso that parts of the subject matter may be eliminated or segregated, as may seem proper, but no additions made to it in any way.

The advantage of such a course of action seems to be that we will not incur six months' delay if the proposal is not passed at this meeting of the Standards Committee. On the other hand, there will be no possibility of it being sent out in any other way than was intended by the Truck Division and a delay of only a month or so will be encountered, as there are frequent meetings of the Truck Division.

MR. MYERS:—As there has always been some objection on the part of the Society to standardizing on design, and as this matter is presented in the report as a design, it should be explained that it is impossible to consider this subject as other than a design, so that the relation between the various component parts can be comprehensively shown. However, as it is offered for adoption it is divided into the various parts shown in the report.

G. L. LAVERY:—Will Mr. Knap include in his amendment the modified title or name of the proposed recommended practice suggested by Mr. Gurney?

MR. KNAP:—I accept the suggestion that the title be amended to include the phrase about roller bearings.

JOHN YOUNGER:—I would like to support Mr. Knap's motion and ask if he will not extend it somewhat. I suggest that action be deferred six months, and during that period be thoroughly discussed by the Society. The standardization of hubs is very important. It means not only the standardization of hubs, but the standardization of bearings, eventual standardization of wheels, and possible standardization of spindles and other devices. It is a big step to take. The last meeting was held on Dec. 16 and obviously the drawings submitted here are not in accordance with the latest views of the Division. I have been given to understand that there are too many detail data on these drawings, such as the size of the fillets.

MR. KNAP:—I think that probably we would "boil" around and not get any further than we have gone, if we made the Division too large. There are over a dozen men on the Truck Division. If we refer the matter to the entire Society, we will probably have so much confusion in six months from now that we will be in just about as bad a boat as we are in now.

MR. YOUNGER:—The subject involves not only trucks, but bearings, axles and wheels, which are handled outside of the Truck Division. The matter is very complex and should be handled patiently.

MR. BRUMBAUGH:—For almost a year this matter has been discussed by those who are most concerned, and

the proposal has the absolute approval of the people in the trade who are really affected by it. The only haste has been in the writing of the report. The long write-up mailed to the members has nothing whatever to do with the practice recommended; it is simply a statement of how the various matters were arrived at, and unfortunately it was prepared in such a way that it does not explain the subject clearly. The substance of the recommendation was scrutinized carefully by the people who are concerned in the practice.

MR. GURNEY:—I would like to request on behalf of the ball bearing industry that consideration of the subject be continued to give the ball bearing manufacturers an opportunity to offer their suggestions. I think that every one here will agree readily that if a common hub standard for ball and roller bearings can be arrived at, it will be of great advantage to all concerned. I wish to support Mr. Younger's request that more time be given to consider the subject.

CHAIRMAN BACHMAN:—In order not to confuse the issue on this matter, Mr. Knap has made a motion for amendment.

[Mr. Knap's motion was seconded.]

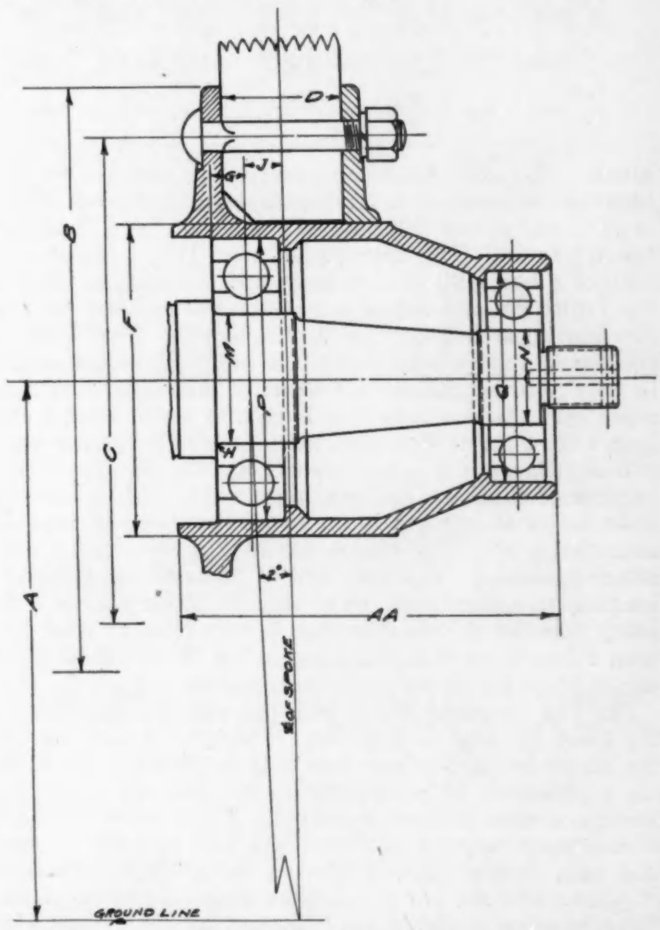
W. E. WILLIAMS:—In the engineering world in which I have been engaged there has been great advancement. I read a motto a great many years ago, which was, "Nothing will ever be accomplished if all possible difficulties must first be overcome." We have debated this subject and should go on record as being in favor of Mr. Knap's motion, sustaining the committee and passing this proposal. Assuming we had done that, what would be the situation? We would be a long way from getting the standards adopted by the axle and bearing manufacturers but we would have put into their mind the fact that something is being done and that they must take notice of it. At the end of six months we can if necessary correct any errors that have been made in the proposal of the committee.

MR. MYERS:—I have been so close to this work for so long that I am very familiar with most of the details. I have argued them back and forth with practically all those interested. It seems to me that what Mr. Williams said is very pertinent. There is much in the proposal that will be of value to the industry. The proposal will not be adopted at once; it may be two, three or four years before there is any general adoption of it. In fact, we have been careful to explain that it is not intended for immediate adoption, but rather to be thought over and worked on in order to make it practical.

It is important that we serve notice on the industry that this subject is being worked on, that the proposal has the approval of the steel wheel, wood wheel, axle and tire and rim industries. There are fundamental differences between roller bearings and the ball bearings. If we delay action on the proposal until we can reconcile those differences I doubt very much whether anything can ever be accomplished. Our plan was to consider ball and roller bearings as totally different types, and to give the industry the best standard we could for roller bearings. With one exception all the truck people are using roller bearings in the structure to which the recommendation of the Truck Division refers. I think the ball bearing people should have a clean sheet to work on when it comes to designing hubs to meet their particular needs. They have conditions to meet which do not concern the roller bearing companies. The program is a long one. It involves a number of steps. If we defer this preliminary step, we may break up our whole program.

MR. GURNEY:—The roller bearing sizes which the Division recommends are not fundamentally different from the sizes of ball bearings that are now being made. If a little more time can be had perhaps the differences can be reconciled.

MR. MYERS:—I have discussed this matter on a number of occasions with two of the important ball bearing manufacturers. While there are bearings in their lists which correspond pretty closely with the dimensions involved in the recommendation before us, the load ratings are not similar to the loads which we had to consider. The accompanying illustration and tables show the ball bearings recommended for these loads by two manufacturers. The outside diameters are ⅛ to ¼ in. larger than recommended for the roller bearings.



HUBS SUITABLE FOR BEARINGS USED ON WHITE TRUCKS
(Dimensions in inches)

Size of Truck, tons	2	3	5
Bearing Nos.	311 308	313 309	315 311
A	18	18	18
B	9⅞	11⅛	12⅜
C	8⅛	9⅜	10⅜
D	2	2¼	2½
F	5¼	6⅛	7
G	0.57	0.65	0.73
H	3/32	3/32	3/32
J	⅝	⅝	⅝
M	2.1654	2.5590	2.9528 2.9518
N	1.5748	1.7716	2.1654 2.1646
P	4.7244	5.5118	6.2992
Q	3.5433	3.9370	4.7244
AA	6 11/32	8 31/32	7 29/32

Our proposal is based on practice; we did not theorize at all. Whenever anything was suggested, we tried to find out what sort of service the particular part had

COMPARISON OF BALL AND ROLLER BEARING RECOMMENDATIONS FOR THE SAME SIZE OF SPINDLE

Hub No.	Bearing	Ball Bearing Recommendations: New Departure		SKF (Hess Bright)		Roller Bearing Sizes: Bore	Outside Diameter	Width
5	Inner	309	3.9370 / 1.7717	1309	3.9370 / 1.7717	1.7500	3.4843	1.5000
	Outer	1306	2.8347 / 1.1811	306	2.8347 / 1.1811	1.1875	2.8593	1.1875
	Inner	310	4.3307 / 1.9685	1310	4.3307 / 1.9685	2.0000	3.9843	1.5000
	Outer	1307	3.1496 / 1.3780	307	3.1496 / 1.3780	1.5000	3.1562	1.1563
7	Inner	311	4.7244 / 2.1654	1311	4.7244 / 2.1654	2.1250	4.3750	1.5000
	Outer	1308	3.5433 / 1.5748	308	3.5433 / 1.5748	1.7500	3.4843	1.5000
8	Inner	313	5.5118 / 2.5591	1313	5.5118 / 2.5591	2.5000	4.7343	1.7500
	Outer	1309	3.9370 / 1.7717	309	3.9370 / 1.7717	2.0000	3.9843	1.5000

given. The only American practice we can find on ball bearings on trucks of 1½-ton capacity and over, which is pertinent to this schedule recommended here, is that of the White Co. The drawing on page 197 shows the design of a hub with the bearings and the spacing used by the White Co. and the table below it shows hubs suitable for bearings used on the White trucks. The table at the top of this column shows the bearings recommended by two representative ball bearing manufacturers. In every case the bearings used by White are at least a size larger than those recommended by the ball bearing companies. There is a case of theory against practice. In a number of cases the ball bearings used by White are two sizes larger than those recommended by the ball bearing manufacturers. The reason for that is that White uses annular bearings at either end of the spindle while the bearing manufacturers offer the double-row type. In every case the spindle diameter is very close to what has been selected, so that grinding a few thousandths more would allow the bearings to interchange.

For the proposed No. 5 hub the outside diameter of the inner bearing is 3.482 in. The outside diameter of the suggested double-row ball bearing is 3.937 in., making a difference of practically ½ in. We could not reconcile any such difference as that. The outside diameter of the inner bearing for the No. 8 hub is 3.981 in. and that of a double-row ball bearing is 4.3307, a difference of ⅓ in. For the No. 7 hub the outside diameter of the inner bearing is 4.372 in., whereas on the double-row ball bearing it is 4.724 in., practically ⅓ in. difference; and for the No. 8 hub the outside diameter of the proposed bearing is 4.731 in., while that of the suggested double-row ball bearing is 5.5118 in., a difference of over ¾ in. in diameter.

There does not seem to be any possibilty of interchanging ball and roller bearings in the same hub, even by allowing a few thousandths difference. We feel that the 95 per cent application has been thoroughly covered in the proposal as it has been presented to various companies all over the country with no resultant adverse criticism.

MR. WILLIAMS:—One of the great difficulties encountered in selling our products abroad is that the foreign dealer is compelled to carry such a variety of supply parts. We figure on selling trucks in Australia, South America and other places where there is a big demand for them, measured by total population, but when the cost of the supply parts that must be carried with the chance of their becoming obsolete is considered, it seems that almost any man would be very bold to engage in carrying our product abroad. We should take action to notify the world that we are going to furnish something that will not involve carrying more supplies than are incorporated in the primary article. I think we would make no mistake in indorsing this report to give notice that this is what we are working toward. The details can be taken up later.

MR. SCAIFE:—Does this proposal bring in a new size roller bearing, or are the sizes recommended all in general practice?

MR. MYERS:—They are all in practice, except one new bearing.

MR. YOUNGER:—I am in favor of hub standardization from the point of view of the manufacturer. The report will eventually be adopted, but it should go through right. The bearing manufacturers are getting together and making arrangements to change the widths of their bearings; the hub people are studying the situation with a view to standardizing on design; and the wheel people are coming together. There is no reason why this report should not be delayed until the Summer Meeting, when something more definite can be adopted.

[On being put to vote both Mr. Knap's amendment and the original motion to approve the Division's report were lost. The matter was referred back to the Truck Division with instructions to reconsider the proposal, consider further suggestions and data which may be received and to prepare a report to be submitted to the Standards Committee at the 1921 Summer Meeting of the Society.]

Following the action taken at the Standards Committee meeting on Jan. 11 when the report of the Truck Division on Hubs for Wood and Metal Wheels was referred back to the Division, members of the Truck Division and the Wheels Subdivision held a meeting in the offices of the Society on Jan. 13 to discuss the action taken at the Standards Committee meeting and to establish a program for further consideration of the report. Those in attendance were A. K. Brumbaugh, chairman; E. L. Clark, H. B. Knap. A. J. Scaife, Cornelius T. Myers, A. S. VanHalteren and R. S. Burnett.

In order that ample notice may be had by everyone interested in this subject and by those who may desire to submit suggestions for consideration by the Division before the final report is formulated in accordance with instructions received at the Standards Committee meeting on Jan. 11, the following resolution was passed and has been approved by letter ballot by 10 out of 14 of the Division members:

> *Whereas*, the Truck Division has prepared and submitted to the Standards Committee of the Society a report proposing the standardization of hubs for wood and metal wheels, and this report was discussed at length in the Standards Committee Meeting and referred back to the Division with instructions to reconsider the subject matter of the report, to give consideration to such suggestions as may be submitted from competent sources and to submit a final report on the proposal for consideration at the meeting of the Standards Committee to be held during the 1921 Summer Meeting of the Society,
>
> *Resolved*, that the Truck Division herewith signifies its readiness to receive and consider suggestions and data submitted from competent sources which bear on the subject of front axle standardization for motor trucks having capacities of ¾ ton and over.
>
> *Resolved* also that to permit of sufficient time for the preparation of this report to the Standards Committee all suggestions and data submitted for consider-

ation should be received by the Standards Department at the Society's offices not later than March 10, 1921.

Resolved further that the Truck Division will hold its last meeting for the preparation of a final report on the proposed hub standardization not later than March 21, 1921.

Attendance at Meeting

The members of the Standards Committee and the Society and the guests in attendance were:

Standards Committee Members

Azel Ames
F. W. Andrew
J. J. Aull
B. B. Bachman
W. H. Bancroft
W. J. Belcher
Joseph Bijur
G. R. Bott
A. K. Brumbaugh
R. S. Burnett
J. F. Caldwell
E. R. Carter, Jr.
D. F. Chambers
W. A. Chryst
E. L. Clark
C. F. Clarkson
W. F. Cole
H. M. Crane
K. W. Dyer
F. L. Eidmann
Bruce Ford
E. S. Fretz
F. P. Gilligan
F. W. Gurney
W. S. Haggott
J. L. Harkness
S. P. Hess
C. E. Heywood
W. E. Holland
F. G. Hughes
E. G. Hulse
E. T. Ickes
E. A. Johnston
L. S. Keilholtz
W. C. Keys
H. B. Knap
G. L. Lavery
B. M. Leece
A. D. T. Libby
W. C. Lipe
H. R. McMahon
C. M. Manly
T. C. Menges
Cornelius T. Myers
W. M. Newkirk
E. Nides
G. L. Norris
Charles Pack
A. J. Scaife
R. A. Schaaf
C. W. Spicer
H. J. Stagg
W. R. Strickland
J. G. Swain
A. L. Swank
S. P. Thacher
J. C. Tuttle
A. S. VanHalteren
J. G. Vincent
K. F. Walker
R. E. Wells
H. F. Wood
R. W. Woodward

S. A. E. Members and Guests

A. H. Ackerman
W. C. Acklin
P. G. Agnew
Harold Almert
R. J. Anderson
V. G. Apple
David Ayr
C. E. Banta
H. E. Bardwell
David Beecroft
J. T. R. Bell
H. E. Brunner
Earle Buckingham
E. B. Busby
Herbert Chase
V. E. Clark
H. E. Clay
R. E. Clingan
J. Coapman
Wm. Cogger
Wallace Core
R. H. Cunningham
P. K. Davis
L. W. DeWitt
N. S. Diamant
E. Dickey
V. W. Dow
E. T. Driver
J. E. Erickson
Powell Evans
Ethelbert Favary
A. W. Frehse
K. W. Gasche
H. R. Gibbons
F. Grutzner
W. J. Hart
S. M. Havens
P. M. Heldt
L. C. Hill
L. S. Homer
F. W. Horenberger
F. W. Huston
H. W. Jackson
J. G. Johnson
R. P. Johnson
T. S. Kemble
S. R. Keuch
G. W. Klinger
Otto H. Lehmann
Benj. Liebowitz
C. R. Mabley
C. R. Manes
E. S. Margolan
L. S. Marshall
J. H. Merrill
Geo. Lee Miller
W. Milne
L. F. Miller
W. J. P. Moore
R. B. Mudge
Glenn Muffly
A. L. Nelson
W. N. Nones
B. A. Parker
A. Z. Pederson
Frank Pollard
R. M. Powell
C. J. Quinn
H. Reisser
W. E. Robertson
D. C. Root
R. E. Rothway
M. P. Rumney
R. T. Russell
H. A. Schatz
J. E. Schipper
Albert Schmidt
R. A. Shaller
F. S. Slocum
A. S. Snyder
R. O. Sperry
J. A. Steinmetz
E. Touceda
S. Tour
Edward Wallace
J. S. Watson
E. W. Weaver
T. A. White
C. B. Whittelsey
W. E. Williams
G. A. Young

TORSIONAL STRENGTH OF MULTIPLE-SPLINED SHAFTS

(*Concluded from page* 130)

sional tests and strain diagrams recently, attention may be called to the fact that the torsion test curve of ductile material is quite different in form from the corresponding tension test curve for the reason that the intensity of stress on any small unit of material at any instant varies with its distance from the axis of the test-piece. Consequently, when the outermost fibers of the specimen have reached their elastic limit, the fibers near the axis of the section are still only slightly stressed. This fact undoubtedly accounts for the comparatively low elastic limit indicated at *c*, the outer layer of material having been greatly weakened by cutting the splines.

AIRCRAFT LAWS

THERE is at the present time no Federal law in existence for the registration of aircraft, nor for the licensing of operators. Under the President's proclamation of Feb. 28, 1918, persons contemplating the operation of aircraft were required to obtain licenses from the Joint Army and Navy Board of Aeronautic Cognizance. This Presidential proclamation was rescinded on July 31, 1919.

The only law which can be considered as controlling air traffic in the United States is that covered in a ruling of the solicitor for the Department of Commerce. The only other restrictions are those contained in local laws and ordinances, in force in States of Connecticut and Massachusetts, the County of Los Angeles, Cal., Atlantic City, Newark and Nutley, N. J., and Kissimmee, Fla.—*Air Service News Letter*.

JANUARY COUNCIL MEETINGS

THE regular January meeting of the Council was held on the 10th with the following present: President Vincent, Past-President Manly, First Vice-President Utz, Vice-Presidents Martin and Wall, Councilors DeWaters and Germane, Treasurer Whittelsey, Chairman David Beecroft of the Meetings Committee and Chairman Brush of the Membership Committee.

Ninety-six applications for membership and enrollment were approved, 18 for Member, 34 for Associate, 23 for Junior, 1 for Affiliate grade of membership and 20 for Student Enrollment.

William P. Hoffman, William M. Stocker, A. J. Langhammer and L. F. Renault were transferred from Associate to Member grade; Arthur L. Collins, R. D. Easton, R. D. Guy and Alexander Taub from Junior to Member grade; and W. P. Loo from Member to Foreign Member.

Past-President Manly was reappointed as a representative of the Society on the American Engineering Standards Committee to serve for a term of three years.

David Beecroft with H. M. Crane as alternate was appointed to represent the Society on the National Advisory Board on Highway Research of the National Research Council.

The following were appointed members of the Research Committee of the Society:

H. M. Crane, *Chairman*, H. L. Horning, H. C. Dickinson, E. A. Johnston, T. C. Menges, Joseph Van Blerck, J. G. Vincent, C. F. Kettering, H. W. Alden and O. C. Berry.

A session of the Council was held on Jan. 11 for the purpose of considering the action taken the same day by the Standards Committee on reports of its Divisions, prior to the submission to the Society in meeting assembled on Jan. 12 of recommendations for S. A. E. Standards and Recommended Practices. Chairman B. B. Bachman reported in detail to the Council the disposition by the Standards Committee of the various Division reports. The action of the Standards Committee was confirmed in all respects.

Organization Meeting of 1921 Council

On Jan. 14 the 1921 Council, whose administrative year began with the conclusion of the Annual Meeting of the Society on Jan. 13, held its organization meeting, the following being present: President Beecroft, Past-President Vincent, First Vice-President Horning, Vice-Presidents Bachman, Crane, Johnston and Menges, Councilors Brush, Davis and Pope, and Treasurer Whittelsey.

G. L. Martin was elected to fill the vacancy in the Council and attended the meeting.

A general discussion was had with regard to policies to be followed during the year, including consideration of the different automotive fields of work in which the Society is engaged. Vice-President Crane and Councilor Martin expressed their views with regard to aviation to the effect that there is much to be done in the matter of establishing rational regulations for the use of aircraft, and in standardization of methods, dimensions and details of various aircraft parts.

Colonel Vincent made a progress report on behalf of the committee of which he is chairman established to advise in connection with the conduct of tire and rim standardization. It was announced that H. H. Rice, representing the National Automobile Chamber of Commerce, and A. L. Viles, general manager of the Rubber Association of America, will serve as members of this committee.

H. R. Corse, who will continue to serve as Chairman of the Sections Committee this year, was present in company with J. A. Anglada and C. B. Veal, members of the 1920 Sections Committee, to report on current conditions in Sections of the Society, for the purpose in part of endeavoring to have the technical work of the Sections fit more closely into that of the Society as exemplified in programs at national meetings.

Vice-President Johnston outlined various important features in the standardization program relating to the vitally important field of farm power engineering. He stated that the fuel problem is just as important in the tractor as in the automobile field.

Vice-President Menges, who has accepted the chairmanship of the Stationary Engine Division, urged that it should be very active and arranged for holding a meeting of the Division in Chicago on Feb. 1.

Councilor Davis, who has been reappointed chairman of the Committee on the Science of Truck Operation, reported in considerable detail on its work, the importance of highway construction and maintenance problems being emphasized. The committee will keep in close touch with the impact-test work of the Bureau of Public Roads of the Department of Agriculture, and the deliberations of the Highway Engineers Association. A principal feature of the work of the committee is the collection of truck operating statistics. The whole program is one of very broad cooperation.

Standards Matters

It was announced that B. B. Bachman will continue to serve as chairman of the Standards Committee. He will be assisted by W. A. Chryst and W. R. Strickland as vice-chairmen of the Committee.

The following appointments of Standards Committee chairmen were announced:

Division	Chairman
Aeronautic	H. M. Crane
Ball and Roller Bearings	W. R. Strickland
Battery (newly established)	Bruce Ford
Chain (silent and roller chains)	W. F. Cole
Electric Vehicle	E. L. Clark
Iron and Steel	F. P. Gilligan
Motorcycle	W. S. Harley
Non-Ferrous Metals	J. J. Aull
Parts and Fittings (succeeding in part Miscellaneous Division)	Clarence Carson
Radiator	J. D. Harris
Springs	R. A. Schaaf
Stationary Engine	T. C. Menges
Threaded Parts	E. H. Ehrman
Tractor	E. A. Johnston
Truck	A. K. Brumbaugh

Administrative Committee

President Beecroft announced the following appointments to Administrative Committees, in addition to those mentioned above:

Meetings Committee—C. F. Scott, *Chairman*, Azel Ames, B. B. Ayers, Howard A. Coffin, H. G. McComb and John R. Cautley.

Publication Committee—Daniel Roesch, *Chairman*, Alexander Klemin, G. A. Young, G. W. Vaughan and H. C. Snow.

Finance Committee—H. M. Swetland, *Chairman*, Alfred Reeves, Christian Girl, G. H. Houston and E. P. Chalfant.

House Committee—H. E. Coffin, *Chairman*, C. F. Kettering, C. M. Vought, H. M. Crane and J. M. Schoonmaker, Jr.

Fuel Research

Following the meeting held on Jan. 10 of the Joint Technical Advisory Committee on Efficient Utilization of Petroleum Products, H. M. Crane was appointed as the representative of the Society to constitute with a representative of the American Petroleum Institute a committee to cooperate with the Bureau of Mines and the Bureau of Standards and direct the expenditure of funds which are or may be appropriated for research work on automotive fuels.

ACTIVITIES OF SECTIONS

Sections Calendar

Boston
Feb. 18—Meeting held in Springfield, Mass.
March 18

Buffalo
Feb. 23—Temperature in Internal-Combustion Engines
April 19—Carbureter Performance

Cleveland
Feb. 18—Systems of Drying by R. E. Lippert

Mid-West
March 11—Storage Batteries

Minneapolis
Feb. 7—Fuels and Fuel Substitutes by Prof. C. A. Norman
March 2—Good Roads and Equipment
April 6—Repair Equipment

Pennsylvania
Feb. 25—Automotive Electrical Equipment

Washington
Feb. 4—Lubrication by Dr. H. C. Dickinson
March 18—Highways and Highway Transport

DURING the Annual Meeting in New York the Sections Committee met to consider ways for increasing and bettering the work of the Sections. To this meeting were invited the officers of all of the Sections and a number of others specially interested, including David Beecroft, the incoming president of the Society, and members of the Meetings Committee.

Chairman H. R. Corse of the Sections Committee, gave a brief outline of the growth of Section membership within the past year. The figures are as follows:

	March 1, 1920	Jan. 1, 1921
Buffalo	121	96
Cleveland	120	200
Detroit	273	366
Indiana	49	75
Metropolitan	213	211
Mid-West	107	[1]133
Minneapolis	99	[1]62
Pennsylvania	73	72
Total	1,055	1,215
Boston (Organized Sept. 22, 1920)		54
Washington (Reorganized Nov. 19, 1920)		25
Total, including new Sections		1,294

[1] Estimated.

The number of Section members on March 1, 1920, was roughly 22 per cent of the membership of the Society at that time, while on Jan. 1, 1921, this proportion had increased to approximately 28 per cent notwithstanding the fact that the number of members of the Society had, during this period, increased rapidly. This reflects in a striking way the considerable interest that is being taken in the activities of the Sections by the members of the Society as a whole. This is beneficial to all and cumulative in its effect. Increased Section membership means more and better Section papers. Better Section programs, in turn, should result in a further increase in membership.

It is felt that the Meetings Committee of the Society can render valuable assistance by informing the Program Committees of the Sections well in advance of the subjects that are to be taken up at the Semi-Annual and Annual Meetings of the Society, enabling the Sections to arrange their programs to cover the same subjects in part at least in a preliminary way. An effort will be made by a number of Sections to concentrate at their meetings during the remainder of their season on Fuel and Research, which will be leading topics considered at the Summer Meeting.

Most of the sections reported their financial status as satisfactory, and it was considered generally that the present annual appropriation by the Society of $500 plus $1 per Section member to each Section, is sufficient, in conjunction with the Section dues, to provide for all necessary expenses.

Members residing in Dayton and adjacent territory met at the Dayton Engineers Club on Jan. 18 and discussed the project of forming a Section of the Society there. Forty-five members and guests were present. As in the cases of the Boston and the Washington Sections started earlier in the winter, there was an overwhelming sentiment in favor of the formation of the Section. A tentative organization was brought about with 45 members and a resolution adopted in which the Council was asked to authorize the operation of the new Section as such. The Standard Section Constitution, By-Laws and Rules were also adopted after the election of officers for the present year as follows:

Chairman, George E. A. Hallett
Vice-Chairman, J. Herman Hunt
Secretary, Richard B. May
Treasurer, Robert F. McCann.

After the successful organization of the new Section, Chas. H. Fox of the Ahrens-Fox Co., gave a talk on the relation of automotive apparatus and fire fighting. The recent growth of the use of internal-combustion engines in this field has been phenomenal and considerable engineering thought is being applied in the connection.

The Buffalo Section listened to a talk on the use of technical motion pictures by T. R. Fessenden on Jan. 18.

Some weeks ago the Minneapolis Section heard the facts about the present status of the tractor industry. This line of thought was continued at the meeting on Jan. 17 when J. L. Record gave his opinion of the future outlook for this industry.

A talk by W. A. Reed, trade adviser of the Pan American Union, on Jan. 7 made clear to the Washington Section some of the export possibilities with South America. This is a subject of never ending interest and one of which most of us have only the slightest knowledge. The future opportunities of profitable trade relations with Latin American countries are so great that first-hand information of local conditions and needs as outlined in Mr. Reed's address provides a foundation of basic knowledge upon which engineering and sales efforts can be built intelligently.

Charles O. Guernsey, chief engineer, Service Motor Truck Co., spoke on Cushioning in Motor Truck Design before the Mid-West Section on Jan. 7. The Indiana Section had the pleasure of hearing Mr. Guernsey talk on The Design of Trucks for High-Speed Service on Jan. 4.

Those who attended the Motor Boat Meeting of the Society in December were interested in a continuation of the Diesel Engine discussion provided by the Pennsylvania Section on Jan. 18. Members of the Section together with a number of out-of-town visitors were invited to inspect the 1750-hp. German submarine Diesel engine now being tested at the League Island Navy Yard. After a dinner at the Engineers' Club the discussion of Diesel engine problems was again taken up. An added feature of the evening was the showing of the Story of Petroleum film which describes the entire oil industry from the drilling operations to the ultimate uses of the various products.

The Metropolitan Section deserves a vote of thanks from the industry for concentrating on the problem of service at its January meeting which was held on the 20th. The inspecton trip through the Willys-Overland service station at New York City, in conjunction with the talk by Cyrus J.

Rankin on Service from an Engineering Standpoint, will bring a clearer realization of the importance of service. Car owners in general are fully aware of the engineering ability displayed by automobile factories in contrast with the lack of it in the majority of service stations. Anything done to improve the work of the service station will have the hearty support of the car owner.

On the evening of Jan. 28 the Cleveland Section, taking advantage of the social opportunities of an automobile show, arranged a Ladies' Night Dinner at which Mayor W. S. Fitz Gerald was the speaker. After the dinner and talk the members and their guests visited the Cleveland Automobile Show.

The Boston Section is contributing in a creditable way to the discussion of the fuel problem. On Jan. 24, Geo. A. Round gave a talk on the subject of Liquid Fuel and led the discussion which followed.

OBITUARIES

FRANK H. BALL, formerly president of the Ball & Ball Carbureter Co., died at Detroit, on Nov. 12, aged 73 years. He was born at Oberlin, Ohio, May 21, 1847, and practically his whole life had been devoted to the invention and manufacture of useful mechanical devices. After graduating from high school at Buffalo he ran a country sawmill on his father's farm and from there went into the production of steam engines for drilling and operating oil wells. The engine which he designed was a large factor in the development of the oil industry of western Pennsylvania and he afterward developed the well-known Ball automatic high-speed steam engine, founding the Ball Engine Co. of Erie, Pa., for its production and serving as its general manager from 1880 to 1890. Subsequently he organized the Ball & Wood Co., Elizabeth, N. J., to continue the building of these engines in the East and in 1895 became president and general manager of the American Engine Co., Bound Brook, N. J., which produced a modified form of his engine known as the American Ball. In 1903 he and his youngest son, Fred O. Ball, designed and built two automobiles. After his retirement from the steam engine business about 1910 Mr. Ball and his son invented and placed on the market the Ball & Ball carbureter for gasoline engines and organized the Ball & Ball Carbureter Co. The manufacture of this carbureter was taken over by the Penberthy Injector Co., and Mr. Ball became associated with that organization in 1913 as manager of the carbureter department, a position which he held at the time of his death. He is survived by three sons and two daughters, his wife having died about three years ago. Mr. Ball had been a member of the American Society of Mechanical Engineers since 1883 and served as one of its vice-presidents from 1894 to 1896. He was elected to Member grade in the Society of Automotive Engineers, Nov. 10, 1915.

CHESTER E. CLEMENS, mechanical engineer of the Standard Parts Co., died on a farm near Madison, Ohio, on Dec. 24, 1920, aged 57 years. He was born on July 12, 1862, at Troy, N. Y. His experience was varied, having served successively as machinist, foreman and superintendent of the Ariel Cycle Co., Goshen, Ind. He next organized the Clemens & Curtiss Co., New York City, and was its superintendent and manager. From here he went with Guieterman, Rosenfeld & Co., New York City, as a buyer of machine tools and products for export. He was next connected with the Cycle & Tool Mfg. Co., Springfield, Mass., as engineer, and from there went to the Massachusetts Automobile Club at Boston, where he was master mechanic. He next entered the service of the Napier Motor Co. of America, which was also located at Boston, as an engineer. Leaving there to accept the position of engineer of the automobile department of the St. Louis Car Co., St. Louis, he subsequently returned to his position as engineer of the Napier company, and from there went to Cleveland as mechanical engineer of the Perfection Spring Co. in 1908. When the Standard Parts Co. was organized Mr. Clemens became mechanical engineer of that organization. He was elected a Member of the Society, Oct. 24, 1908.

WILLIAM T. PRICE, chief engineer of the oil engineering department of the Ingersoll-Rand Co., Phillipsburg, N. J., died Nov. 7, 1920, at the age of 37 years. He was born Sept. 28, 1883, at Montreal, Quebec, Canada. Following his preliminary education in the Toronto Technical School he entered Cornell University and was graduated in 1906 as a mechanical engineer. Previous to his entrance to Cornell he had been employed as a draftsman in the design of small hoisting equipment, blast-furnace and steel mill equipment, and during his college course he was an assistant instructor in machine design.

From 1906 to 1918 he filled several engineering and managerial positions, specializing in the designing, selling and installing of stationary oil engines during the latter part of this period.

Subsequent to 1918, he was president of the Price Engineering Corporation, New York City; president of the P-R Engine Co.; second vice-president of the Rathbun-Jones Engineering Co., Toledo, Ohio, and chief engineer of the oil engineering department of the Ingersoll-Rand Co. He was a member of the Engineers' Club, New York City, and of the American Society of Mechanical Engineers. He was elected to Member grade in the Society of Automotive Engineers, July 19, 1918.

MODERN MACHINE TOOLS

THERE are, perhaps, two outstanding advances in principle in machine work which have run in parallel with the progress of car building, namely, machining by grinding and the discovery or development of high-speed tungsten steel for cutting tools. Upon these depends the possibility of present-day rapidity of production of the class of machined parts demanded in a modern car. The first made it possible to remove small amounts of material quickly and accurately from hardened as well as from soft objects. The second enables very large amounts of material to be removed with reasonable accuracy and so quickly that a great advance was necessary in the stability of machine tools, the methods of holding and driving the work or object and the horsepower required to drive the machine.

The combination of these two advances seems to have been responsible for any "spurt" in progress, for in about 1906 we found in machines employed on the production of the car parts a good demand for and a good supply of "all geared" heads, quick-change feed-gears and a great extension of the principle of bringing different cutting tools to bear upon the object being machined. Anything in the nature of a revolution seems to have occurred about this date, and a general increase in the use of time-saving machines engaged on car construction then took place.—A. J. Hancock in *Auto*.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Dec. 10, 1920, and Jan. 10, 1921. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member. (F M) Foreign Member; (E S) Enrolled Student.

ACKLIN, JAMES M. (M) vice-president and manager, Acklin Stamping Co., *Toledo, Ohio,* (mail) 1645 Dorr Street.

APPLEBY, FRED (M) designer, Holt Mfg. Co., *Peoria, Ill.,* (mail) 108 Wisconsin Avenue.

ARMSTRONG, J. ALLAN (A) soliciting agent, Allegheny Steel Co., Brackenridge, Pa., (mail) 1436 Dime Bank Building, *Detroit.*

AUSTIN, SYDNEY BERTRAND (M) engineer, Eisemann Magneto Corporation, 32 33rd Street, *Brooklyn, N. Y.*

BAKER, BRYON G. (A) general manager, Canadian Tillsoil Farm Motors Co., 704 Canada Building, *Winnipeg, Man., Can.*

BARNARD, GEORGE A., 2ND (A) acting automotive engineer, Graton & Knight Mfg. Co., *Worcester, Mass.,* (mail) 356 Franklin Street.

BARNES, WILLIAM B. (J) assistant in experimental laboratory, Cadillac Motor Car Co., *Detroit,* (mail) 246 Mount Vernon Avenue.

BICKNELL, G. M. (M) chief engineer, Carter Carburetor Co., 2838 North Spring Avenue, *St. Louis.*

BOOTH, HARRY T. (J) aeronautical engineer, Curtiss Aeroplane & Motor Corporation, Garden City, N. Y., (mail) 25 Fredericks Avenue, *Freeport, N. Y.*

BORNSTEIN, JOSEPH (A) chief engineer and works manager, American Metal Parts Corporation, Boston, (mail) 113 Howard Avenue, *Boston* 25.

BRACKENRIDGE, J. H. (J) chief engineering clerk, Cleveland Tractor Co., *Cleveland.*

CHESNUT, FRED H. (A) transportation engineer, White Co., 1490 Market Street, *San Francisco.*

CLARK, WILLIAM T. (M) factory manager, Fuller & Sons Mfg. Co., *Kalamazoo, Mich.,* (mail) 314 Stuart Avenue.

COULTER, JAMES (M) vice-president, Automatic Machine Co.. *Bridgeport, Conn.*

DOANE, C. W. (M) district representative, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., (mail) 1109 Kresge Building, *Detroit.*

DOOLITTLE, H. P. (M) general patent attorney, International Harvester Co., 606 South Michigan Avenue, *Chicago.*

DUTCHER, F. H. (M) instructor, Columbia University, 117th Street and Broadway, *New York City.*

EASTON, J. A. G. (J) engineer and manager, Ericson Aircraft Ltd., *Toronto, Ont., Canada,* (mail) 267 McPherson Avenue.

EVERETT, CHARLES J. (M) vice-president, Everett Bros., Inc., 320 Broadway, *New York City.*

EVERETT, WILLIAM T. (M) superintendent, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., (mail) Frankstown Road and Hochberg Street, *Wilkensburg, Pa.*

FRALICK, L. J. (A) assistant sales manager, Hydraulic Pressed Steel Co., 3152 East 61st Street, *Cleveland.*

GAIDOS, ALONZO F. (J) draftsman and tool designer, 1185 The Alameda, *San Jose, Cal.*.

GILMORE, ROGER J. (A) president, Hare's Motors of New England, 700 Commonwealth Avenue, *Boston.*

GILSON, A. (A) mechanical engineer, Packard Motor Car Co., *Detroit,* (mail) 2966 Hurlbut Avenue.

GORDON, CHARLES (A) sales engineer, Foote-Burt Co., Cleveland, (mail) 120 Wisconsin Street, *Milwaukee, Wis.*

HARRIMAN, DANIEL F. (M) chief engineer, Scientific Automotive Corporation, Hoboken, N. J., (mail) 4 Jones Street, *Jersey City, N. J.*

HAVENS, SAMUEL M. (A) assistant treasurer and works manager, Ingalls-Shepard Division, Wyman-Gordon Co., *Harvey, Ill.*

HELMBOLDT, WERNER (A) superintendent, department of motor transportation, City of Detroit, (mail) 403 City Hall, *Detroit.*

HOURWICH, ISKANDER (J) aeronautical mechanical engineer, engineering division, Air Service, McCook Field, *Dayton, Ohio,* (mail) 122 Arnold Place Apartments.

HUGHES, RALPH C. (M) engineer, Teetor-Hartley Motor Corporation, *Hagerstown, Ind.*

HUNT, ERNEST C., JR. (M) assistant superintendent, Morse Chain Co., *Ithaca, N. Y.,* (mail) 108 North Aurora Street.

HUNTER, HARRY M. L. (A) salesman, Cincinnati branch, Jones & Laughlin Steel Co., *Pittsburgh.*

JOSLIN, FRED A. (J) draftsman, Allison Experimental Co., *Indianapolis,* (mail) 2455 North Talbott Avenue.

KEAN, JOHN SCOTT (J) designer, Naval Aircraft Factory, League Island Navy Yard, *Philadelphia,* (mail) 1630 North Sydenham Street.

KLINEDINST, L. M. (M) manager, farm tractor and implement division, Timken Roller Bearing Co., *Canton, Ohio,* (mail) 2531 Tuscarawas Street, West.

LEJEUNE, FRANK H. (J) manager, steel division, Hayes Wheel Co., *Jackson, Mich.,* (mail) 810 Wildwood Avenue.

LIEBERMAN, A. W. (M) engineer and production manager, Tracking Trailer Co., *Cleveland,* (mail) 2198 East 80th Street.

LIMBOCKER, CHARLES C. (A) president, Wolverine Tube Co., 1411 Central Avenue, *Detroit.*

LOTZ, WALTER PHILIP (A) tool supervisor, International Motor Co., New Brunswick, N. J., (mail) 314 Harper Place, *Highland Park, N. J.*

MARX, HARRY J. (A) consulting engineer, Van Muffling & Marx, New York City, (mail) 702 Chauncey Street, *Brooklyn, N. Y.*

MEDWEDEFF, MARSHALL H. (M) 5014 Wesley Avenue, *Howard Park, Baltimore.*

MITNICK, JACOB J. (J) automotive engineer, Armour Institute of Technology, *Chicago.*

NELSON, ARNE T. (M) master mechanic, Anderson Electric Car Co., Detroit, (mail) 260 McLean Avenue, *Highland Park, Mich.*

NELSON, HENRY C. (M) vice-president and general manager, Mullins Body Corporation, *Salem, Ohio,* (mail) 135 Lincoln Avenue.

NICHOLS, W. W. (A) mechanical engineer, D. P. Brown & Co., *Detroit,* (mail) 1440 Park Place.

NIHLEAN, F. R. (J) draftsman, Stromberg Motor Devices Co., *Chicago,* (mail) 6147 Champlain Avenue.

NOE, SHEROD S. (J) chief engineer, Tool & Auto Products Co., East 73rd and St. Clair Avenue, *Cleveland.*

OSTERHELD, CLARK M. (M) chief engineer, Stoughton Wagon Co., *Stoughton, Wis.*

PATTERSON, ARTHUR E. (J) assistant to C. S. Ricker, consulting automotive engineer, *Indianapolis,* (mail) 3534 North Capitol Avenue.

REES, FRED H. (A) director of sales and sales manager, Willys-Overland Co., 1631 Broadway, *New York City.*

RICE, FRED D. (A) Eastern sales representative, Eaton Axle Co., Cleveland, (mail) 197 Atlantic Street, *Bridgeton, N. J.*

RICE, WALTER J. (M) secretary and treasurer, Fox Motor Car Co., *Philadelphia,* (mail) 4553 Uber Street.

RYON, HERBERT C. (A) service manager, Watson Products Corporation, Canastota, N. Y., (mail) 329 Coolidge Avenue, *Syracuse, N. Y.*

SCOTT, JOHN (M) assistant works manager, Olds Motor Works, *Lansing, Mich.,* (mail) 409 Bartlett Street.

SCOTT, NELLIE M. (A) president and general manager, Bantam Ball Bearing Co., *Bantam, Conn.*

SELENSKY, FLOYD B. (J) draftsman, Waterloo Gasoline Engine Co., *Waterloo, Iowa,* (mail) 928 West Second Street.

STREIT, N. B. (A) sales engineer, Tide Water Oil Sales Corporation, 11 Broadway, *New York City.*

TERRY, EDWARD JAMES (A) general foreman, Holt Mfg. Co., *Peoria, Ill.*

THORNE, MAURICE A. (J) assistant physicist, Bureau of Standards, *Washington,* (mail) Tunlaw Road, Northwest.

TOULMIN, HARRY A., JR. (A) patent lawyer, Toulmin & Toulmin, *Dayton, Ohio.*

VAWTER, H. L. (M) chief engineer, Parenti Motors Corporation, *Buffalo,* (mail) 63 Delaware Road.

WARDWELL, H. F. (A) general sales manager, Detroit Steel Products Co., *Detroit.*

WARNER, CAPT. WALTER W. (S M) department of engineering, Coast Artillery School, *Fortress Monroe, Va.*

WEBB, PAUL ST. ELMO (A) transportation engineer, Diamond T. Truck Co., *Nashville, Tenn.,* (mail) 1207 16th Avenue, South.

WILLIAMS, FRANK (J) draftsman, Stout Engineering Laboratories, 37 Churchill Avenue, *Detroit.*

WILSON, HERBERT L. (M) draftsman, in charge of aeronautical design, bureau of engineering, Navy Department, *Washington,* (mail) 104 13th Street, Northeast.

WILSON, LESTER T. (A) technical representative, National Lead Co., Chicago, (mail) 129 York Street, *Brooklyn, N. Y.*

WILSON, ROBERT W. (J) Vulcan Motor Axle Corporation, *Detroit,* (mail) Carola Apartments, 42 Watson Street.

ZIEBELL, A. C. (A) secretary, Universal Foundry Co., *Oshkosh, Wis.*

Vol. VIII February, 1921 No. 2

Applicants *for* Membership

The applications for membership received between Dec. 28, 1920, and Jan. 28, 1921, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

BAIRD, LYMAN BAIRD, production manager, Clifton-Holmes Products, *Detroit.*

BAXTER, CAPT. OTHEL, supervisor, automotive department, educational and recreational school, *Camp Dix, N. J.*

BEST, NORMAN A., engineer, Dow Chemical Co., *Midland, Mich.*

BOVELL, SAMUEL C., superintendent of equipment, Magnolia Petroleum Co., *Dallas, Tex.*

BROWN, LOWELL H., president, Belflex Corporation, *New York City.*

BRYANT, WILLIAM L., president and manager, Bryant Chucking Grinder Co., *Springfield, Vt.*

BURCH, FERDINAND L., assistant chief engineer, Preferred Motor Car Co., *Indianapolis.*

BURGELEIT, W. H., draftsman, Durant Motors, Inc., *Long Island City, N. Y.*

CAMPBELL, J. GORDON, foreman, Willys-Overland Ltd., *Toronto, Ont., Canada.*

CARNEGIE, WILLIAM, draftsman, Cadillac Motor Car Co., *Detroit.*

CARPENTER, W. W., sales engineer, H. H. Knepper, *Detroit.*

CLIFF, H. G., banker, Routt County Bank, *Oak Creek, Col.*

CORE, EUGENE D., assistant manager and consulting engineer, McIntyre Motor Co., *Kalamazoo, Mich.*

CORFF, EDWARD VINCENT, assistant engineer, American Car & Foundry Co., *Chicago.*

DALEY, FRANK R. L., chief inspector, Northway Motor Corporation, *Natick, Mass.*

DAVIS, STUART B., engine designer, Haynes Automobile Co., *Kokomo, Ind.*

DEPUY, CLARENCE E., professor of mechanical engineering, Lewis Institute, *Chicago.*

DESONIA, LLOYD J., student, Virginia Vocational High School, *Virginia, Minn.*

DUNN, WILFRED J., chief engineer, Forster Motor Car & Mfg. Co., Ltd., *Maisonneuve, Que., Canada.*

DYER, KIRK W., president, Frisbie Motor Co., *Middletown, Conn.*

EARL, HERMON, chief engineer, John W. Henney & Co., *Freeport, Ill.*

EINSTEIN, ARTHUR W., traffic engineer, Ward La France Truck Co., *Elmira, N. Y.*

ELMENDORF, ARMIN, consulting engineer, 819 Chamber of Commerce Building, *Chicago.*

FARR, HENRY W., sales manager, Johnson Carburetor Co., *Detroit.*

FESLER, J. A., special representative, Bassick Mfg. Co., *Chicago.*

FITZGERALD, M. L., president and general manager, Forster Motor Car & Mfg. Co., *Montreal, Que., Canada.*

FONTE, ALBERT L., student, Virginia Vocational High School, *Virginia, Minn.*

GAGE, V. R., assistant professor of experimental engineering, Sibley College, Cornell University, *Ithaca, N. Y.*

GESCHELIN, JOSEPH, production engineer, Duplex Engine Co., Inc., *Brooklyn, N. Y.*

GOSS, RAY B., instructor, Purdue University, *Lafayette, Ind.*

HALE, WINFIELD, factory manager and chief engineer, Stutes-Mar Tractor Co., *Sunnyvale, Cal.*

HARBUTT, JOHN E., inventor of automobile accessories, *Cicero, Ill.*

HARRIS, HOWARD C., salesman, Akron Rubber Mold & Machine Co., *Akron, Ohio.*

HARVEY, JAMES D., assistant research engineer, Stewart-Warner Speedometer Corporation, *Chicago.*

HATHORN, CHARLES E., designer, Curtiss Aeroplane & Motor Corporation, *Garden City, N. Y.*

HILL, N. A., consulting industrial engineer, *Baltimore, Md.*

HOLBROOK, FRANK, chief inspector, Russel Co. branch of McCord Mfg. Co., *Detroit.*

HUPP, R. C., automotive engineer, Detroit Athletic Club, *Detroit.*

JANERY, WALTER R., general service manager, Clark Tructractor Co., *Buchanan, Mich.*

JENKINS, HARRY E., head of radiator sales department, U. S. Cartridge Co., *Lowell, Mass.*

JOHNSON, A. E., draftsman, Holt Mfg. Co., *Stockton, Cal.*

KEISLER, SCOTT W., 62 West Alexandrine Avenue, *Detroit.*

KELLEY, E. A., sales representative, Splitdorf Electrical Co., *Newark, N. J.*

KING, W. GRIFFIN, general sales department, Aluminum Manufactures, Inc., *Cleveland.*

KINGSNORTH, HERMAN, warrant officer, Marine Corps, *Washington.*

KLOCK, FRANKLIN G., assistant to supervising engineer, Sinclair Refining Co., *Chicago.*

LANDRY, JOSEPH E., president and engineer, Landry Mfg. Co., Inc., *New Bedford, Mass.*

LARSON, J. LYMAN, instructor in agricultural engineering, University of Minnesota, *St. Paul, Minn.*

LEYERLE, FRANK J., assistant factory manager, Splitdorf Electrical Co., *Newark, N. J.*

LINCOLN, W. C., engineer, National Railway Appliance Co., *New York City.*

LINNEY, WILLIAM A., foreman, dynamics laboratory, Aluminum Manufactures, Inc., *Cleveland.*

LORING, THOMAS W., body engineer, Republic Motor Truck Co., Inc., *Alma, Mich.*

MCHUGH, THOMAS A., tire salesman, 427 Amsterdam avenue, *New York City.*

MCKENNA, A. W., chief inspector, Osgood Bradley Car Co., *Worcester, Mass.*

MCKINNON, ERNEST C., electrical engineer, Chloride Electrical Storage Co., Ltd., *Manchester, England.*

MALKMUS, GEORGE A., instructor, Rahe Auto School, *Cincinnati.*

MOODEY, A. W., automotive engineer and assistant sales manager, Sherwin-Williams Co., *Cleveland.*

MUNSON, WILLIAM C., branch manager, Russell Mfg. Co., *Middletown, Conn.*

MYERS, WILLIAM M., experimental engineer, Johnson Carburetor Co., *Detroit.*

PARKER, HUMPHREY F., assistant engineer physicist, Bureau of Standards, *Washington.*

PEARSON, LESLIE W., president, Giant Motor Truck Co., Ltd., *Vancouver, B. C., Can.*

POPPE, PETER A., technical director, White & Poppe, Ltd., *Coventry, England.*

POWELL, WILLIAM L., general foreman and body engineer, Preston Motors Corporation, *Birmingham, Ala.*

PRATT, JAMES M., assistant to general manager, Northway Motors Corporation, *Natick, Mass.*

PRESTON, VICTOR, chief body engineer, Hayes Ionia Co., *Grand Rapids, Mich.*

RUTLEDGE, C. B., president, Southern Electric Service Co., *Memphis, Tenn.*

SANDERS, WILLIAM E., experimental engineer, Burch Service Co., *Indianapolis.*

SCHAEFER, LOUIS P., service man, Elizabeth Auto Co., *Elizabeth, N. J.*

SEYMOUR, GLEN F., trouble investigator and layout man, Cleveland Automobile Co., *Cleveland.*

SHEFFIELD, EARL A., equipment representative, Bethlehem Spark Plug Co., Inc., *Bethlehem, Pa.*

SMALL, A. R., vice-president, Underwriters' Laboratories, Inc., *Chicago.*

SORENSEN, CLARENCE S., mechanical engineer, C. M. Gay & Son, *Los Angeles, Cal.*

STEWART, JAMES L., vice-president and general manager, Thomart Motor Co., *Akron, Ohio.*

STRANG, W. H., factory manager, L. C. Graves Co., *Springboro, Pa.*

SUDDUTH, ARTHUR L., instructor in ignition, School of Engineering, *Milwaukee, Wis.*

TAAFFE, RANDAL DUNNE, mechanical engineer, owner of machine shop and distributor for Hares Motors Products, *Santa Barbara, Cal.*

THOMA, LOUIS, engineer, Advance-Rumely Co., *Clearing, Ill.*

THOMAS, S. J., sales engineer, Canton Rim Co., *Louisville, Ohio.*

TIGAR, M. GEORGE, treasurer, M. George Tigar Bearing Co., Inc., *New York City.*

TRESSLER, ROBERT L., salesman, I. J. Cooper Rubber Co., *Dayton, Ohio.*

TWYMAN, THOMAS C., sales manager, G-A Ball Bearing Mfg. Co., *Chicago.*

UPTON, G. B., professor of experimental engineering, Cornell University, *Ithaca, N. Y.*

VANCIL, E. D., draftsman, Garford Motor Truck Co., *Lima, Ohio.*

VON GOGH, EDWARD P., vice-president and general manager, U. P. C. Book Co., Inc., *New York City.*

VAN SANDWYK, MARINUS C., student automobile mechanics, Sweeney Auto School, *Kansas City, Mo.*

VON THADEN, HERBERT, student, Massachusetts Institute of Technology, *Cambridge, Mass.*

WALKER, GILBERT DUNSTAN, production and efficiency engineer, Hartford Automotive Parts Co., *Hartford, Conn.*

WARNER, FRANCIS J., district engineer, Standard Oil Co., *Spokane, Wash.*

WASSERFALLEN, C. F., factory manager, Detroit Carrier & Mfg. Co., *Detroit.*

WATSON, L. E., general manager, Clovis Motor Co., *St. Marys, W. Va.*

WEBER, EUGENE A., chief engineer, Gardner Motor Co., Inc., *St. Louis.*

WEISSINGER, HORACE L., superintendent, automobile body department, Osgood Bradley Car Co., *Worcester, Mass.*

WERNER, J. F., chief body engineer, Kissel Motor Car Co., *Hartford, Wis.*